

107E-5558-JWH
6 May 2004

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BY:



Mr. Patrick Quinn
Missouri Department of Natural Resources
Hazardous Waste Program
1738 East Elm Street
Jefferson City, Missouri 63101

RE: Comments Concerning the McDonnell Douglas RCRA Facility Investigation (RFI) Report, Hazelwood, Missouri; Permit # MOD000818963

Encl: Revised RCRA Facility Investigation Report for McDonnell Douglas, Hazelwood, Missouri

Dear Mr. Quinn;

Following is our response to your April 6, 2004 comment letter on the RFI Report for the Boeing Facility. We feel that all comments have been adequately addressed and the report revised accordingly. For your ease in reviewing the enclosed report, all revisions are shown in red. Final copies of the report will be printed and submitted following your approval.

GENERAL COMMENT

- Agree.

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RCRA RECORDS

SPECIFIC COMMENTS

1. Section 2.3 Investigation History, pages 2-2 through 2-4.

- Agree.

2. Section 2.6.1 Bedrock Geology, page 2-5.

- The source of the bedrock map has been referenced on Figure 2-5.
- Bedrock elevation data is from the Facility and SLAPS and a reference has been added to the text along with a data table presenting the SLAPS and the Facilities depth to bedrock.
- The discussion of the development of the Florissant Basin has been expanded.
- A stratigraphic column describing the sequence of bedrock present in the St. Louis Area has been added as Figure 2-5, along with text describing formations below the St. Louis and St. Genevieve Limestone.

- A discussion of the general permeability characteristics of the bedrock has been added to Section 2.7.1.

3. Section 2.6.2 Unconsolidated Materials, Lake Sediments, page 2-7.

- The discussion of the events leading to the development of the Florissant Basin has been expanded.
- Added the word "horizon (bed)" after organic silt on page 2-7.

4. Section 2.7.1 Limestone Bedrock, page 2-8.

- Additional discussion of the referenced report by Miller, 1974 has been added along with the discussion of the bedrock geology underlying the Post-Maquoketa Aquifer (Maquoketa Shale that is 100+ feet thick and constitutes a confining unit (aquitard) as discussed in Section 2.6.1.)
- Additional referenced material has been included regarding evaluation of groundwater in the Area.

5. Section 2.7.3 Surficial (Unconsolidated) Material, page 2-9.

- The silt "horizon" has been made the top of the confining unit and Figure 2-11 (Figure 2-12 in the revised draft) revised to show that change.
- Agree that there is little flow of water in or through the confining unit, added text to Section 2.7.3 and 2.7.3.2.

6. Section 2.7.3.1 Shallow Groundwater Zone, page 2-9.

- Text in Section 2.7.3.1 has been reworded to make it clear that the RFI is not comparing SLAPS data to Facility data but that the differences in geochemical analysis between the shallow and deep groundwater follows a similar pattern as observed at SLAPS.
- SLAPS data is available in referenced citations.

7. Section 2.7.3.2 Deep Groundwater Zone, page 2-10.

- Reference to bedrock map has been added to Figure 2-5.
- A reference to the artesian conditions seen at MW-9D has been added to Section 2.81.
- A discussion of the vertical gradient has been added to the section.

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- Information regarding pure, laboratory grade solvent effect on hydraulic conductivity has been added to Section 2.7.3.2.
- The discussion of groundwater results for the deep zones have been broken out separately and expanded in the relevant parts of Sections 4 and 5.

8. Section 2.8.1 Groundwater Elevations, Deep Groundwater Zone, page 2-13.

- MW10D was drilled to refusal on bedrock and a more permeable unit was not encountered.
- MW11D is set on shale bedrock and there is no evidence of a unit between the shale and limestone bedrock.
- From Section 2.8.1 “Although the deep groundwater is within a confined groundwater zone and not directly hydraulically connected to Coldwater Creek, the deep groundwater is expected to flow to the northeast down the Coldwater Creek valley”.

9. Section 2.8.2 Hydraulic Conductivity, Pump Test, page 2-14.

- The comparison to glacial till has been changed to a comparison to silty clay.
- A discussion of the subsurface structure present very near the pumping well MW-7S has been added.
- Geometric mean has been used to recalculate the hydraulic conductivity for the Facility to match the calculation used for SLAPS.

10. Section 2.9 Surface Water-Coldwater Creek, page 2-16, 17.

- The discussion of the average stream flow has been modified using USGS stream gauge results from the gauge located at the McDonnell Boulevard.
- Boeing is not evaluating the USACE data; the RFI is only presenting the conclusions from the referenced SLAPS reports. The data that led to these conclusions are available in the referenced SLAPS reports (see response to Comment #1).
- The minimum flow that could be identified by the USGS study has been added to the RFI text.
- A discussion of PAHs has been added from the SLAPS Baseline Risk Assessment that concluded, “concentrations determined at SLAPS (including Coldwater Creek sediments) might not be exceptional for the area or have originated from past operations at SLAPS (Argonne, 1993)”.

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11. Section 4.1 Study Area A-Upgradient Parcel, page 4-1.

- A brief description of past use of the area where the Engineering Campus buildings are located has been added. Since there are no boring or wells in the area of Study Area A that was formerly owned by Curtiss-Wright (basically where Building 27A is located) and there is no evidence of impact to this area observed in wells downgradient (MW9S, MW8) further discussion of past land use was not added.
- A discussion of the UST formerly located in Study Area A has been added along with the letter from Boeing documenting their field screening in these areas.

Section 4.1.2 Investigation Results, Soil, page 4-1.

- Changed to background anthropogenic vehicle emissions, etc.

12. Section 4.2 Study Area B-North Office Complex

Section 4.2.1.3 Investigation Results, Trash Compactor Hydraulic System, page 4-3.

- The groundwater results from boring B220N1 are discussed in greater detail to indicate that further investigation is not warranted.

Section 4.2.2.3 Investigation Results, Groundwater, page 4-4.

- Agree.

13. Section 4.3 Study Area C – GKN Area

Section 4.3.2 Division C (2), SWMU 8 Scrap Dock Shelter, page 4-6.

- Text has been added regarding the conditional closure of SWMU 8.

Section 4.3.2.3 Investigation Results, Soil, page 4-8.

- Cutting oil type petroleum was observed in RC2 as discussed in added text.
- TCE impact has been adequately delineated to east by borings inside Building 27

Section 4.3.2.3 Investigation Results, Groundwater, page 4-8.

- Revisions have been made to the source areas descriptions in Section 4.3.2.1
- Text has been added regarding the piezometers, which are screened between 16 and 24 feet and are in the zone intermediate to the shallow and deep groundwater.
- MW9S has been sampled 11 times and never had a VOC detection, indicating that TPH is not present, it will, however, be sampled for TPH and the results incorporated in the final RFI.

Section 4.3.3.3 Investigation Results, Soils, page 4-12.

- The suspected source of TPH impact are machinery pits, additional information has been included in the section along with a copy of the sump/pit inspection report as an Appendix.

Section 4.3.3.3 Investigation Results, Groundwater, page 4-12.

- The industrial sewer serviced the entire Building 27; a small vapor degreaser was also located outside the electroplating room and has been added to the text.

14. Section 5.1 Study Area D –SWMU 17, page 5-1.

SWMU 2 Waste Nitric/Hydrofluoric Acid Storage, page 5-1.

- Information on closure of SWMU 2 has been included in text.

Airport USTs, page 5-5.

- Off-site impacts are clearly migrating onto the Boeing site as evidenced by B51W2 and the referenced/included Airport UST data.

Section 5.1.3 Investigation Results, Soil and Groundwater, pages 5-6 through 5-10.

- Agree, however migration of TPH from off-site investigation should be conducted by the off-site property owner.

15. Section 5.2 Study Area E, page 5-10.

Section 5.2.1.3 Jet Fuel Hydrant Area, Investigation Results, Soil/Groundwater, page 5-11.

- Additional discussion of the previous investigation and remedial action conducted at SWMU 14 and Jet Fuel Hydrant Line has been added.
- Areas of Concern included in Section 5.2.1.1 account for the impact observed in the area.

Section 5.2.2.3 Hush House, Investigation Results, Soil/Groundwater, page 5-14.

- Additional discussion of the previous investigation and remedial action conducted at Hush Houses has been added.
- Necessity for monitoring will be determined in the Corrective Measure Study.

Section 5.2.4.3 Industrial Sewer Line, Investigation Results, Soil/Groundwater, page 5-14.

The section of sewer repaired in Area E (4) has been identified on Figure 5-11

Section 5.2.5.3 Building 41, Investigation Results, Soil/Groundwater, page 5-20.

- Discussion of impact to deep groundwater has been broken out and the probable source (drum storage outside of Building 40) identified in the text.

Section 5.2.6.3 Building 1/2 USTs, Investigation Results, Soil/Groundwater, page 5-21.

- See risk assessment.

16. Section 5.4 Study Area G, page 5-25.

Section 5.4.2.1 Investigation Results, page 5-27.

- TPH concentration detected in SB21B5 was just above ITL; the source for this minor detection is unknown. See Risk Assessment.

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17. Section 6.1.2 Groundwater Metals Analysis, page 6-3.

- A statistical analysis of groundwater metal concentration is included in the RFI.

18. Volume 2 Tables

- Each laboratory used had a slightly different analyte list, even for the same method, therefore, if a lab did not analyze for a specific compound that was detected by another laboratory it would show up in the table as NA. Bromodichloromethane and dichlorodifluoromethane in Table 4-16 are examples of this. If a sample was only analyzed for BTEX and MTBE, instead of a full VOC scan, it was noted in the table notes as in Table 5-1.

19. Volume 3 Figures.

Figure 2-11 General Hydrogeologic Column.

- Figure 2-11 (Figure 2-12 in revised RFI) has been revised to show silt as the top of the deep/confining unit.

Figures 4-5 and 4-6 Soil/Groundwater Detections.

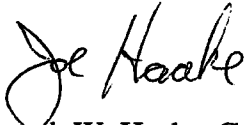
- The extent of impact above ITL has been slightly modified in the vicinity of the Recycling Dock.

Figures 6-1 and 6-2 Soil/Groundwater Detections Above ITLs

- The extent of impact above ITL has been slightly modified in the vicinity of the Recycling Dock.

Please contact me if you have any questions.

Sincerely,



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c: Ms. Joletta Golik, Lambert-St. Louis International Airport
Ms. Demetra Salisbury, U.S. EPA Region VII

Draft

**RCRA Facility Investigation Report
for McDonnell Douglas,
Hazelwood, Missouri**

Volume I – Text



~~October 22, 2003~~ May 2004

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List of Abbreviations and Acronyms

Airport	Lambert St. Louis International Airport	OD	outside diameter
AST	aboveground storage tank	ORP	redox potential
ATV	all terrain vehicle	PAH	polynuclear aromatic hydrocarbons
bgs	below ground surface	PCB	polychlorinated biphenols
BNI	Bechtel National, Incorporated	PCE	perchloroethylene
BTEX	benzene, toluene, ethylbenzene, and total xylenes	PCOCs	potential chemicals of concern
CALM	Cleanup Levels for Missouri	PID	photoionization detector
cm/sec	centimeters per second	ppm	parts per million
cm ² /sec	centimeters squared per second	PR	Preliminary Review
CMS	Corrective Measures Study	PRG	preliminary remediation goal
COCs	constituents of concern	PVC	polyvinyl chloride
cfs	<u>cubic feet per second</u>	RA	risk assessment
4°C	degrees Celsius	RCRA	Resource Conservation and Recovery Act
4°F	degrees Fahrenheit	RFA	RCRA Facility Assessment
DO	dissolved oxygen	RFI	RCRA Facility Investigation
DQL	Data Quality Level	SAIC	Science Applications International Corporation
DQO	Data Quality Objective	SC	specific conductivity
DRO	Diesel Range Organics	SLAPS	St. Louis Airport Site
EAs	Environmental Assessments	SWMUs	Solid Waste Management Units
ESA	Environmental Site Assessment	TCE	trichloroethane
Facility	Boeing Tract 1 facility	TOV	total organic volatiles
FS	Feasibility Study	TPHs	total petroleum hydrocarbons
ft/ft	feet per foot	USACE	U.S. Army Corps of Engineers
FUSRAP	Formerly Utilized Sites Remedial Action Program	USCS	Unified Soil Classification System
gpm	<u>gallons per minute</u>	USEPA	U.S. Environmental Protection Agency
GRO	Gasoline Range Organics	USGS	U.S. Geological Survey
HDPE	high density polyethylene	UST	underground storage tank
HI	hazard index	VOC	volatile organic compounds
HISS	Hazelwood Interim Storage Site	VSI	Visual Site Inspection
HSA	hollow-stem auger		
HWP	Hazardous Waste Program		
HZ	hydrostratigraphic zone		
ID	internal diameter		
ITLs	Investigative Threshold Levels		
IWTP	industrial wastewater treatment plant		
kPa	<u>kilopascals</u>		
MCL	maximum contaminant level		
MCLG	maximum contaminant level goal		
MDNR	Missouri Department of Natural Resources		
MEK	methyl ethyl ketone		
µg/kg	micrograms per kilogram		
µg/L	micrograms per liter		
mg/L	milligrams per liter		
MIBK	methyl isobutyl ketone		
MSD	Metropolitan St. Louis Sewer District		
msl	mean sea level		
MTBE	methyl tertiary-butyl ether		
NPDES	National Pollutant Elimination System		

1.0 Introduction

This document represents the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Corrective Action activities completed at McDonnell Douglas, a wholly owned subsidiary of the Boeing Company (Boeing). The Boeing Tract 1 facility (Facility) is located in Hazelwood, Missouri. The Facility location is presented in Figure 1-1.

The Facility is subject to the requirements of Corrective Action as outlined in the final RCRA Part B Permit Number MOD000818963. A renewal of this permit was issued by the Missouri Department of Natural Resources (MDNR) on March 5, 1997 pursuant to Section 3004(u) of RCRA. This RFI Report has been prepared in accordance with Corrective Action Permit Conditions I, VI, and XIV and the MDNR-approved RFI Work Plan and Work Plan Addendums dated November 24, 1997, March 16, 2000, and July 19, 2001.

Further guidance, as needed, was obtained from documents including the "RCRA Facility Investigation Guidance" [U.S. Environmental Protection Agency (USEPA) 530/SW89-031], "Test Methods for Evaluating Solid Waste" (SW-846), and other relevant USEPA publications. This RFI Report (Report) fully complies with the Corrective Action requirements of the Facility's Part B Permit.

1.1 Purpose

This RFI Report documents the investigation activities conducted to characterize the nature of any hazardous waste/constituent releases to soil or groundwater from the five Solid Waste Management Units (SWMUs) as prescribed in the RFI Work Plan. This RFI also documents the investigative activities conducted to identify and characterize the extent of any petroleum or hazardous waste/constituent releases to soil or groundwater at other areas of potential concern identified as part of transactional Environmental Assessments conducted between 2000 and 2003. This RFI Report will provide MDNR/USEPA personnel with Boeing's evaluation and conclusions regarding the RFI data. Upon review and approval by MDNR, this Report will serve as a reference document and database for the development of a Risk Assessment and for planning future Corrective Action activities at the Facility, as needed.

1.2 RFI Report Organization

This Report is divided into ~~ten~~seven sections of text plus ~~nine~~12 appendices. A brief description of each section is presented below.

Section 1.0, **Introduction**, provides background information regarding the RCRA requirements for the Facility, purpose of this Report, and contents of this Report.

Section 2.0, **Facility Background Information**, references background information regarding the Facility and its environmental setting.

Section 3.0, **Investigation Methods and Objectives**, summarizes the RFI field activities and describes the procedures that were utilized for field sampling and laboratory analysis tasks. This section also summarizes the field investigation objectives, identifies the target constituents and associated investigation threshold levels (ITLs) for the RFI, and describes the established data quality objectives for the investigation.

Section 4.0, **Tract 1-North Investigative Results**, summarizes the field activities conducted in the Tract 1 North area along with the analytical results.

Section 5.0, **Tract 1-South Investigative Results**, summarizes the field activities conducted in the Tract 1 South area along with the analytical results.

Section 6.0, **Facility Wide Summary and Conclusions**, summarizes the RFI investigation results and presents conclusions which address the RFI objectives.

Section 7.0, **References**, provides a list of references used within the text of this RFI Report.

Nine appendices are also provided to describe associated RFI activities. Appendices to this document are identified below.

- Appendix A presents the soil boring logs for the U.S. Army Corps of Engineers (USACE) and Metropolitan St. Louis Sewer District (MSD) bedrock borings.
- Appendix B presents a summary of groundwater measurements.
- Appendix BC presents copies of laboratory reports for soil samples collected for geotechnical analysis.
- Appendix CD presents copies of soil borings and monitoring wells completed as part of the RFI.
- Appendix DE presents a summary of groundwater sampling field parameter measurement results.
- Appendix EE presents electronic copies of soil and groundwater laboratory reports and chain-of-custody forms.
- Appendix G presents the Boeing underground storage tank (UST) removal letter dated April 21, 2004 to the MDNR.
- Appendix FH presents a copy of the Phase 2 subsurface investigation report for the Building 220 vapor degreaser.
- Appendix I presents the report on visual inspection of Building 27 machining area sumps by Heritage Environmental Services.

- Appendix ~~G~~J presents documentation of the Building 27 industrial sewer repair in 2000.
- Appendix ~~H~~K presents a copy of the statistical evaluation of metals in groundwater, Boeing Tract 1.
- Appendix ~~I~~L presents a summary of laboratory analysis for biological degradation indicator parameters.

2.0 Facility Background Information

2.1 Site Description

The Boeing Tract 1 Facility (Facility) is located in the City of Hazelwood in St. Louis County, Missouri (Figure 2-1). The Facility is located at latitude 38.75 degrees North and longitude 90.36 degrees west. The Facility is bordered on the south, southeast, and southwest by Lambert St. Louis International Airport (Airport), on the east by the Formerly Utilized Facility Remedial Action Program (FUSRAP) St. Louis Airport site-Site (SLAPS)-site, on the west by Lindbergh Boulevard, and on the north by McDonnell Boulevard and various commercial and industrial facilities. In general, the Facility is located in a highly urbanized (industrial/commercial) setting. Tract 1 is divided into two sections: Tract 1-South (approximately 108 acres) is located south of Banshee Road; and Tract 1-North (approximately 120 acres) is located north of Banshee Road. There are approximately 80 buildings located within Tract 1 (North and South).

In 2001, Boeing sold a portion of the North Tract containing Buildings 27 and 29 to GKN Aerospace. Boeing is in the process of vacating the South Tract and turning the buildings and land over to the owner, Lambert St. Louis International Airport. This process is scheduled to be completed by mid-2004. Boeing is retaining the Engineering Office Complex consisting of Buildings 32, 33, and 34 along with office and warehouse facilities in Buildings 220 and 221. Figure 2-2 presents an ownership map for the Facility.

2.2 Facility Operations

Aerospace manufacturing has been in continuous operation at the Facility since 1941. The Facility activities primarily consisted of the manufacturing of fighter aircraft and components. Processes include the fabrication of aluminum, titanium, composite structures, and other air frame material. The manufacturing processes also include metal cutting, metal forming and grinding, degreasing, painting, aircraft assembly, aircraft fueling, and aircraft flight testing.

Access to the Facility is strictly controlled. The Facility is surrounded by a chain-link fence and is patrolled by a security force 24 hours a day, 365 days per year. Employees and visitors must pass through security gates at the main entrance to the Facility before entering any building.

The Facility was permitted to store hazardous waste under RCRA permit number OSO 62284002. The Facility was also permitted to transport hazardous wastes from other Boeing (St. Louis) facilities for management and solvent recycling.

Boeing generated approximately 48 different waste streams that the Facility considered to be hazardous waste. The largest quantities of wastes generated consist of emulsified cutting oils, waste jet fuels, paint solids, solvent and paint wastes, wastewater treatment sludges, and acid

and caustic wastes. Boeing stores hazardous waste at various locations around the Facility. Waste solvents, paints, and oils are accumulated in drums at numerous satellite accumulation locations. Boeing stored on-site-generated waste in drums at three less-than-90-day storage areas. Non-petroleum liquid wastes are either transported off-site for disposal, or neutralized and processed through the industrial wastewater treatment plant (IWTP). Liquids pretreated in the IWTP are discharged to the ~~Metropolitan St. Louis Sewer District (MSD)~~ publicly-owned treatment works under an industrial discharge permit. Petroleum wastes are stored in tanks or drums, and either blended and used as fuel for boilers (off-spec jet fuel only) or transported to a disposal facility. Sludge from the IWTP is transported to an off-site disposal facility.

In the past, Boeing operated three solvent distillation units which were certified as resource recovery units by the MDNR. Two of the distillation units were used to recover spent methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK). One of these was located at the painting area in Building 27 and the other was located at the main paint booth in Building 48. Distillation bottoms were collected in 55-gallon drums and disposed as hazardous waste. The other distillation unit was a steam stripping carbon adsorption bed unit that recovered spent perchloroethylene (PCE) and was located in Building 51.

A total of approximately 6870 ~~underground storage tanks (USTs)~~ have been located at the Facility since operations began in 1941. These USTs primarily have been used to store pure petroleum products (jet fuels JP-4 and JP-5, gasoline, diesel, and hydraulic oil) along with waste petroleum products (jet fuels, used oil). At various times, three USTs at the Facility were used to store solvents and lacquer thinner. A total of 11 USTs are currently in use at the Facility, three on the North Tract and eight on the South Tract. A summary listing of all known USTs at the Facility is presented in Table 2-1. Locations of the former and current USTs are presented on Figure 2-3.

There are five locations at the Facility where petroleum products were stored that contained or may have contained lead additives. These locations are:

- Tanks B52 and B53 (vehicular gasoline) at Building 22 [Study Area C(2), see Section 2.4];
- Tank B68 (aviation gasoline) at the aviation gasoline refueling station located between Building 42 and Building 2 [Study Area E(1)];
- Tanks B3 (aviation gasoline) and B4 (vehicular gasoline) at the Building 41 tank farm [Study Area E(5)];
- Tanks 20 and 21 (gasoline for emergency generator) at the Building 1 emergency shelter [Study Area E(6)];
- Tank 23 (vehicular gasoline) at the Building 1 executive garage [Study Area E(6)].

Note that the jet fuels (JP-4, JP-5, and JP-8) used at the Facility did not contain lead or methyl tertiary butyl ether (MTBE) additives. JP-4 is a jet fuel that was used to power Air Force aircraft.

JP-4 as a fuel was replaced by JP-8 in a phased process beginning in 1991 and ending in 1996. JP-4 is a 50/50 heavy naptha/kerosene blend containing 20 to 25 percent aromatics and 0.5 percent benzene (by weight). JP-8 is a refined kerosene containing 5 to 25 percent aromatics and 0.0028 to 0.8 percent benzene by weight (Kampbell, 2000). JP-5 was developed by the Navy for aircraft used aboard ships and is similar to JP-8 with a higher flash point. For comparison, automotive gasoline contains around 1.9 percent benzene (API, 1985). Lead and MTBE are not listed as approved additives in military spec jet fuels JP-4, JP-5, or JP-8 (Military Specifications MIL-T-5624P, MIL-F-5624B, MIL-DTL-83133, respectively) and, therefore, should not be present in jet fuel or in the subsurface impacted by a jet fuel release.

2.3 Investigation History

Numerous investigations have been completed at the Boeing Tract 1 Facility, including document and operation reviews, visual inspections, and sampling efforts. These investigations have been conducted as part of the RCRA program [RCRA Facility Assessment (RFA) and RF]), USTs removals and/or investigations, and environmental assessments with subsequent environmental investigations.

2.3.1 RCRA Program

The RFA, consisting of the Preliminary Review (PR), Visual Site Inspection (VSI), and a sampling visit, was completed in 1995. The PR consists of a file review of inspection reports, permits, historical monitoring data, and interviews. The VSI consists of an on-site inspection and interviews with Facility personnel. The PR and VSI identified a total of 32 SWMUs at the Facility. The RFA recommended soil sampling at select SWMUs. The SWMUs at the Facility are presented in Table 2-2 and shown on Figure 2-3.

Based upon the RFA results and discussions with MDNR, an RFI was conducted in 1998. The RFI investigated five SWMUs (10, 17, 21, 26, and 31) and resulted in the development of a Draft RFI Report (QST, 1998). SWMU 17 was further investigated in subsequent studies (Harding ESE, 2001a), which included soil borings, monitoring wells, and quarterly groundwater monitoring (Harding ESE, 2002a).

Interim measures were completed at SWMUs 10, 22, 26, and 28 in 1997 [Heritage Environmental Services, Inc. (HES), 1997]. The interim measures taken at these SWMUs are discussed in the study area descriptions in Sections 4.0 and 5.0.

2.3.2 Environmental Assessments

Several background studies were completed as part of the transactional audits for the Boeing Tract 1. These studies included:

- Environmental Baseline Survey, Naval Weapons Industrial Reserve Plant, St. Louis, Missouri (Tetra Tech NUS, Inc., 2000). This study included a search of Facility and government records and a visual walk through site inspection. The study included only

the Navy property, which had been leased to Boeing. This consisted of Buildings 20, 22 through 28, 30, 39, and surrounding areas on Tract 1-North.

- Environmental Site Assessment (ESA) of Buildings 21, 29, and 29A (HES, 1999). This Phase I ESA encompassed part of Tract 1 North and included a records search, interviews with Facility representatives, and a government database review.
- ESA of Boeing Property B-North (HES, 2000). This Phase I ESA encompassed part of Tract 1-North and included a records search, interviews with Facility representatives, and a government database review.
- Environmental Baseline Survey, Missouri Air National Guard Site, Hazelwood, Missouri (Golder Associates, 2003). The objective of this study was to analyze existing documentation, conduct visual surveys, and interview appropriate personnel to document the environmental condition of the Boeing Tract 1 South property.
- Environmental Field Investigation Statement of Work for Boeing Tract 1 South Property, Hazelwood, Missouri Facility (Harding ESE, 2002b).

2.3.3 Environmental Investigations

Based upon the Environmental Assessments (EAs), several environmental investigations (soil and/or groundwater sampling) were conducted. These studies included:

- Phase 2 Environmental Site Assessment Report for Boeing Fabrication Operations Facility. St. Louis, Missouri (Volumes 1 and 2) [Environmental Science and Engineering, Inc. (ESE), 2000].
- Phase 2 Environmental Site Assessment Report for Boeing Fabrication Operations Facility. St. Louis, Missouri (Volume 3) (Harding ESE, 2001b).
- Environmental Field Investigation for Boeing Tract 1 South Property, Hazelwood, Missouri Facility (MACTEC, 2003).
- Phase 2 Subsurface Investigation, The Boeing Company, Building 220 (Wellington Environmental, 1999).
- Visual Inspection of Machining Area Sumps – Building 27 (HES, 2000).

2.3.4 UST Investigations

Several studies have been conducted as part of UST removals and/or investigations of UST releases. These studies included:

- Hydrogeologic Assessment and Soil Vapor Survey, McDonnell Douglas Corporation, St. Louis, Missouri [ATEC Environmental Consultants (ATEC), 1990].
- Hydrogeologic Assessment at the McDonnell Douglas Aircraft Complex. St. Louis, Missouri (Burns & McDonnell, 1989).
- McDonnell Douglas Remediation Project, St. Louis, Missouri (Reidel, 1990).
- Subsurface Site Investigation and Monitoring Well Installation, McDonnell Douglas Corporation (Petrochem Services, Inc., 1988).
- UST Closure Report (UST#0005887), McDonnell Douglas Corporation Fuel Farm #43 (Tri-Tech Environmental Services, Inc., 1991).

- UST Closure Report (UST#0005954), McDonnell Douglas Aerospace Building 25, St. Louis, Missouri, Methanol Tank (Cardinal Environmental Operations, 1994).
- UST closure samples, Building 20, The Boeing Company, St. Louis, Missouri (ESE, 2000).

2.4 Study Areas

In order to facilitate the evaluation of the investigation results, the Facility has been divided into 18 study areas (Figure 2-4). A list of the study areas and the associated SWMUs, USTs, aboveground storage tanks (ASTs), or other areas of potential concern is presented in Table 2-3.

2.5 Environmental Setting

The climate of the St. Louis area is classified as modified continental. The average daily temperature ranges from 45.4 to 65.5 degrees Fahrenheit (°F). The highest average monthly temperature is 89°F in July and the lowest average monthly temperature is 19.9°F, in January. Normal annual precipitation is slightly more than 35 inches. Average annual snowfall is 26.3 inches. Prevailing winds tend to be from the south in the summer and fall at average speeds of 8.7 miles per hour, and from the west and west-northwest in the winter and spring, averaging 11 miles per hour [Bechtel National, Inc. (BNI), 1990].

2.6 Geology and Hydrology

The geology and hydrogeology of the Facility and surrounding area (North County area) has been extensively studied during investigations conducted at both the Facility (ATEC, 1990; Riedel, 1990; Burns & McDonnell, 1989; and QST, 1998) and the adjacent SLAPS [BNI, 1994; Science Applications International Corporation (SAIC), 1995; SAIC, 1998a; SAIC, 1998b; MDNR, 1987, and U.S. Army Corps of Engineers (USACE), 2003]. These studies have included the completion of numerous soil borings, monitoring wells, and piezometers, the analysis of soil and groundwater samples, aquifer pump and slug tests, a groundwater geochemical study, geotechnical studies, and a surface water and sediment study of Coldwater Creek. In addition, several publications are available that describe the geology/hydrogeology of the region [Brill, 1991; Lutzen and Rockaway, 1971; Miller, 1997; Miller et al., 1974; Rockaway and Lutzen, 1970; U.S. Geological Survey (USGS), 1993; Thompson, 1995; and Thompson, 1986]. These studies and publications allow the development of a comprehensive conceptual model of the geology and hydrogeology at the Facility.

2.6.1 Bedrock Geology

The Facility is located on generally flat topography in an area known as the Florissant Basin (Figure 2-5). The Florissant Basin consists of a broad valley cut by the ancestral Coldwater Creek and tributaries, developed over an old valley that drained north to the Missouri River in pre-Pleistocene time and was occupied by a predecessor of the present Coldwater Creek. This

valley or basin was subsequently in-filled by unconsolidated clay, silt, and sand deposits up to approximately 100 feet thick.

The bedrock formations that underlie the Facility area are presented in Figure 2-6. Starting from the oldest (deepest) to the youngest, these formations consist of the

- Maquoketa Group (Shale),
- Fern Glen Formation,
- Burlington-Keokuk Limestone,
- Warsaw Formation,
- Salem Formation,
- St. Louis Limestone,
- Ste. Genevieve Formation,
- Cherokee Group, and
- Marmation Group.

The St. Louis Limestone, Ste. Genevieve Formation, Cherokee Group, and Marmation Group are the uppermost bedrock formations underlying the unconsolidated materials in proximity to the facility (Figure 2-5). The Maquoketa Shale constitutes a confining unit (aquitard) that prevents significant groundwater flow to underlying formations (refer to section 2.7 Hydrogeology).

The bedrock units underlying the unconsolidated deposits consist of the Mississippian Age St. Louis limestone, Ste. Genevieve limestone, (underlain by the St. Louis limestone), and the Pennsylvanian Age Cherokee, and Marmaton Groups (Brill, 1991). The Ste. Genevieve limestone underlies the center of the Florissant Basin, which is bordered by the Cherokee Group, followed by the Marmaton Group (see Figure 2-5). A top of bedrock elevation map was prepared using boring data collected from the Facility (refer to Table 2-43-4) and SLAPS and is presented in (is presented in Figure 2-76). The bedrock elevation drops from an elevation of approximately 472 feet mean sea level (msl) at the western side of the Facility to approximately 448 feet msl near Coldwater Creek. A linear depression in the bedrock surface is apparent east of Coldwater Creek (see Figure 2-67). This linear depression may represent the ancestral channel of Coldwater Creek.

The following presents a description of the bedrock formations (oldest to youngest) within the Facility area, according to Thompson (1995) and MDNR (1987):

- **Maquoketa Group** has been divided into four formations; Girardeau Limestone, Orchard Creek Shale, Thebes Sandstone, and Cape La Croix Shale (Thompson, 1991). In eastern Missouri, the group merges northward into a single shale (Thompson, 1991), with thickness in the Facility area of approximately 100 feet.
- **Fern Glen** is approximately 40 feet thick and consists of red shaley limestone and shale.

- **Burlington-Keokuk Limestone** is approximately 120 feet thick and consists of a white to gray crystalline limestone with abundant chert.
- **Warsaw Formation** is approximately 75 feet thick and consists predominantly of gray shale, interbedded with dolomite and limestone.
- **Salem Formation** is approximately 120 feet thick and consists of interbedded limestone, shale, and dolomitic shale.
- **St. Louis Limestone**, underlying the ~~Ste. Genevieve~~ formation, is approximately 100 feet thick and consists of a white to light gray finely crystalline, medium to massive-bedded limestone. Chert is not common and thin shale beds are located throughout the formation. Parts of the formation are locally dolomitic.
- **Ste. Genevieve Limestone** consists of a white, massive-bedded, sandy, clastic limestone. It is generally coarsely crystalline and oolitic, but does contain a few beds of finely crystalline limestone. The lower part of the formation is sandy, white to light-tan or light-olive-gray, and is prominently cross-bedded and ripple-marked. In the St. Louis area, the formation is approximately 30 feet thick.
- **Cherokee Group** in the study area consists of the Cabaniss subgroups and includes the Scammon, Croweburg, and Lagonda Formations with an aggregate average thickness of about 75 feet. The Scammon Formation in this area consists of a lower gray shale, the Tiawah limestone member, and the Chelsea micaceous sandstone member with a total combined thickness of about 4 to 8 feet. The Croweburg Formation in this area consists of a lower thin limestone, a massive black shale, a micaceous siltstone or sandstone, an underclay, and at the top of the Croweburg, a coal bed, with a total combined thickness of about 20 feet. The Lagonda Formation in this area consists of lower sandy and micaceous shale beds and upper sandstone or siltstone beds with a total combined thickness of about 55 feet (MDNR, 1987).
- **Marmaton Group** has been divided into two subgroups: Fort Scott and Appanoose. The Fort Scott Subgroup in this area consists of a thin basal Blackjack Creek limestone, a modest thickness of shale, and at the top a modest thickness of Houx limestone with a total combined thickness of about 20 feet.

The Appanoose subgroup consists of the LaBette Formation, the Pawnee Formation, the Bandera Formation, the Altamont Formation, and the Nowata Formation with an aggregate average thickness of about 80 feet.

The LaBette Formation in this area consists of a lower thick shale or clay and a thin upper coal with a total combined thickness of about 10 feet. The Pawnee Formation in this area consists of about a 2- to 4-foot thickness of the Myrick Station limestone member. The Bandera Formation in this area consists of about 15 feet of shale. The Altamont Formation in this area consists of about a 5-foot thickness of limestone of the upper Worland member. The Nowata Formation in this area consists of shale, siltstone, and sandstone with a combined total thickness of about 25 feet (MDNR, 1987).

2.6.2 Unconsolidated Materials

The unconsolidated (surficial) materials overlying bedrock at the Facility and adjacent SLAPS consist of clay, silt, and sand with minor amounts of gravel. The location of the cross sections in plan view is presented in Figure 2-78. Two geologic cross sections, one across the North Tract and one across the South Tract, were prepared (Figures 2-89 and 2-910) using soil borings and monitoring wells installed at the Facility. The following presents a generalized description of these materials in ascending order [(bottom oldest) to top (youngest)]:

- **Basal Sands and Gravels** – In several areas, sand and/or gravel intervals have been noted at the top of bedrock. These materials are due to erosion and deposition at the bedrock surface prior to the deposition of the overlying silts and clays. Typically, these intervals are only 1 to 2 feet thick, and in most cases contain a significant percent of clay, reducing the permeability. This interval at the top of bedrock is described as “Glacial clayey gravels, sands, and sandy gravels. Mostly chert” by the USACE (2003) and as residuum (material derived from in-place weathering of the underlying bedrock) by MDNR (1987). It is likely that both processes were involved in the generation of the basal sand/gravel interval. The chert gravel within a dense clay matrix, observed in some borings, is considered typical of a weathered limestone bedrock. The clean (low clay/silt content) sands and gravels observed in other borings, however, are more representative of fluvial or glaciofluvial processes. The occurrence of these clean sands/gravels was observed at only one location ~~of~~ at the Facility, monitoring well MW9D, and does not constitute a contiguous lithologic or hydrologic unit.
- **Residuum** – As stated above, residuum is derived from the in-place weathering of bedrock. The basal sands and gravels (which may be considered residuum) are discussed above. The MDNR (1987) stated that the residuum in the area may be up to 15 feet thick. The SLAPS studies did not identify a separate residuum unit. During remedial and geotechnical investigations on the western side of Tract 1 South (SWMU 17 area), a dense shaley clay (weathered shale), approximately 15 to 20 feet thick was observed above bedrock. No basal sands or gravels were observed in this area. Clearly, this shaley clay unit would be classified as residuum. In the areas underlain by limestone, a red-brown clay, 10 to 20 feet thick with occasional gravelly or sandy intervals, was noted. This may represent a bedrock residuum. The boundary between the residuum and the overlying lake deposits is difficult to distinguish on soil boring logs.
- **Lake Sediments** – During the Pleistocene, the Florissant Basin consisted of a lake (Lake Brussels) caused by backwater flooding due to a Pleistocene age ice dam on the Mississippi River near the Chain of Rocks. This ice dam ponded water in the Mississippi and Missouri rivers valleys to about elevation 550 feet and formed Lake Brussels. This also flooded the old north-draining valley now occupied by Coldwater Creek. In the still waters of the lake, thick sediments were deposited. The resulting lake sediments consist predominantly of clay and silt and have a high degree of vertical and horizontal heterogeneity. In general, there is an increase in clay content with depth. In some soil

borings, a varved (thin layered) clay was observed. A very distinct (1 to 4 feet thick) organic silt with abundant wood fragments was observed in most soil borings at the Facility. A top of organic silt elevation isopleth map is presented in Figure 2-10¹. The organic silt level drops from an elevation of approximately 541 ft msl at the western end of the Facility to an elevation of approximately 511 feet near Coldwater Creek. The organic silt horizon (bed) is used as a "stratigraphic marker" to correlate the unconsolidated geologic units at the Facility. The varved clay and organic silt clearly indicate a lacustrine depositional environment. The average thickness of the lake sediments is approximately 50 to 75 feet.

- **Loess** – Overlying the lake sediments is a layer of loess approximately 10 feet thick. The loess consists of wind blown silt and clay with typically a light brown or olive gray color. This loess is most likely the Peoria Loess (Wisconsinan Stage). In general, the water permeability in the loess unit is slightly higher than the underlying lake sediments. Prominent soil mottling was commonly observed in the soil samples along with manganese stains/nodules and iron-cemented concretions.
- **Fill** – The uppermost section at the Facility consists of reworked silt/clay material sometimes mixed with bricks, wood, etc. The thickness of this unit ranges from 0 to approximately 10 feet.

2.7 Hydrogeology

The hydrogeologic units at the Boeing Facility are presented in Figure 2-14². The hydrogeologic units consist of limestone bedrock, shale bedrock, deep surficial groundwater, and shallow surficial groundwater.

A total of eight private wells were identified within a 3-mile radius of the FUSRAP North County site consisting of SLAPS and the Hazelwood Interim Storage Site (HISS) (USACE, 2003). These wells range in depth from 35 feet to 400 feet and none of these are used for drinking water. Four of these wells had been used for irrigation and one for industrial purposes. The three other wells had been used for domestic use and were capped and abandoned in 1962, 1968, and 1979 (BNI, 1992). Most of these wells are installed into fractured bedrock where better yields can be obtained as compared to the shallow unconsolidated formation (USACE, 2003). Only one well was identified within one mile of the Facility (Golder and Associates, 2003). This well was reported to have been installed in 1968 to a depth of 44 feet as an observation well. The well is located approximately 0.5 mile southwest of the Facility in the area of the current westward airport expansion.

Therefore, the groundwater underlying the Facility is not currently used as a drinking water supply and is not likely to be used for this purpose given the industrial/urban setting and the availability of the public water supply system.

Additionally, the area around SLAPS and HISS does not contain any ecologically vital groundwaters (Vinikour and Yin, 1989). Ecologically vital groundwaters are those supplying a sensitive ecological system that supports a unique habitat, i.e. those that either are used by federal-listed or proposed endangered or threatened species or are federal land management areas congressionally designated and managed for the purpose of ecological protection.

2.7.1 Limestone Bedrock

The Ste. Genevieve and St. Louis limestones can produce useable quantities of groundwater, but have highly variable yields. High yields can be obtained from fractured bedrock or within solution voids with low yields from more massive portions of the bedrock.

Two boreholes at the nearby SLAPS were completed in the uppermost limestone, underlying the unconsolidated material (Bechtel, 1992). These borings (B53G16 and B53G18, shown on Figure 2-6) encountered generally hard, well cemented limestone, without encountering significant voids or cavities. The limestone was interbedded with low permeability shale. Field permeability (packer) tests were performed in these boreholes with a resulting average hydraulic conductivity of 2.9×10^{-6} centimeters per second (cm/sec) (USACE, 2003). The MSD completed a borehole into bedrock near Coldwater Creek and Building 5 (Figure 2-6) in 2003 (TSI, 2003). This boring encountered bedrock at approximately 81 feet. The bedrock consisted of generally massive limestone with interbedded chert and shale. A few small solution features and fractures were noted but most were filled with clay. Based upon the results from these borings, the bedrock is considered massive and has limited development of secondary porosity. Copies of the boring logs for the USACE and MSD borings completed into bedrock are included in Appendix A.

The Ste. Genevieve and St. Louis limestones are known in some areas to have karst development (sinkholes/caves), but this is typically where the formations are exposed at the surface. Surface exposures are subject to more intensive weathering and solution. The bedrock at the Facility is overlain with approximately 50 to 70 feet of low permeability clay which reduces weathering and dis-solution of the limestone.

The Ste. Genevieve and St. Louis Formations limestone aquifers are included in considered as the Group 1 (Post Maquoketa) aquifers by Miller (Miller et al., 1974). The Group 1 aquifers are underlain by the Maquoketa Shale (Figure 2-6), which acts as an aquitard and prevents significant interaction between the Group 1 Aquifers and underlying aquifer groups (Miller et al., 1974). The Maquoketa Shale is considered part of the Ozark Confining Unit (Imes and Emmett, 1994). The following presents Miller's description of the Group 1 aquifers.

"Group 1 (Post-Maquoketa) Aquifers – Water from Group 1 aquifers varies from a calcium-magnesium-bicarbonate type to a sodium-sulfate, sodium-bicarbonate, or a sodium-chloride type. The dissolved-solids content is quite variable, ranging

from 246 to 6,880 milligrams per liter (mg/L). The water is generally low in iron and very hard. Slightly more than 75 percent of the wells sampled yielded water containing less than 0.3 mg/L of iron. Hardness of water from most of the wells was greater than 180 mg/L. Fluoride content of the water is relatively high. In 50 percent of the samples, the fluoride content was greater than 1.4 mg/L.

The data indicates that just over 50 percent of the wells sampled yielded potable water. These wells are, for the most part, near the outcrop line of Meramecian Series rocks (St. Louis, Salem, and Warsaw Formations) of Mississippian age, and, based upon the 25 percentile values, they yield predominantly calcium-magnesium, bicarbonate type of water. The higher dissolved-solids contents in water from Group 1 aquifers are from an area just north and northwest of the city of St. Louis in St. Louis County, and in extreme southeastern St. Louis County. Water in these areas generally is a sodium-chloride type, but it may also contain large amounts of calcium and sulfate. Variations in the predominant chemical characteristics between the calcium-magnesium-bicarbonate type and the sodium-chloride type are presumably related to the effects of geologic structure, the movement of water from overlying or underlying formations into Group 1 aquifers, and to the presence of certain minerals in the parent rock.

Waters having a high sulfate content are, for the most part, limited to the area underlain by rocks of Pennsylvanian age. These rocks comprise shales, sandstones, and siltstones that locally have minor amounts of pyrite and gypsum. These fine-grained rocks are relatively impermeable; however, over a large area, they could yield enough seepage to explain some of the sulfate anomalies in the study area."

The Facility is located in an area that is not considered favorable for the development of high-yield wells in bedrock aquifers due to "yields generally less than 50 gallons per minute (gpm) in shallow aquifers containing potable water; deeper aquifers yield saline water" (Miller et al., 1974, Figure 11, p. 20). The Facility is in an area mapped as having high chloride content (approximately 50 mg/L) in the uppermost (Group 1) limestone bedrock aquifer (Miller et al., 1974, Figure 12, p. 28). High sulfate concentrations were also reported for areas underlain by Pennsylvanian age rocks, which would include the Facility due to the presence of the Cherokee and Marmation Groups. Therefore, the water quality of the uppermost bedrock aquifer is likely poor and not suitable as potable water.

2.7.2 Shale Bedrock

The Pennsylvanian age shales, interbedded with thin sandstone, siltstone, coal, and limestone beds, do not produce usable quantities of groundwater due to their low permeability. These

formations are considered an aquitard or barrier to groundwater flow and, in part, protect the lower limestone (Group 1) aquifers from potential impacts from the surface.

2.7.3 Surficial (Unconsolidated) Material

Based upon lithology, occurrence of groundwater and groundwater geochemistry, the surficial groundwater has been divided into two zones: shallow groundwater and deep groundwater (see Figure 2-142). These two groundwater zones are separated by low permeability clay (aquitard). The aquitard is included in the deep groundwater zones due to the presence of groundwater within the zone. The understanding of the surficial hydrogeology is based on studies conducted at the Facility and (in part) on the extensive studies conducted at the adjacent SLAPS.

2.7.3.1 Shallow Groundwater Zone

This unconfined groundwater zone extends from the land surface to the ~~basetop~~ top of the organic silt ~~or the top that overlies~~ that overlies the dense clay. Groundwater is typically encountered at 4 to 14 feet below ground level. The lithology consists of fill material, loess, and the uppermost beds of the lake deposits. The shallow groundwater zone at the Facility correlates with the SLAPS hydrostratigraphic zone (HZ) A (USACE, 2003). At SLAPS, the shallow groundwater was characterized by highly variable groundwater geochemistry including elevated levels of sulfates, calcium, nitrate, sodium, and chloride compared to deep groundwater (USACE, 2003).

Geochemical analysis of groundwater samples collected from eight pairs of nested monitoring wells (i.e., adjacent shallow and deep wells) at the Facility was conducted as part of the RFI. The results of these analyses indicate ~~similar~~ similar differences in groundwater geochemistry between the shallow and deep groundwater zones observed at the Facility similar to those observed at SLAPS. The conductivity, chloride, and sulfate concentrations were higher in the shallow groundwater while iron concentrations were highest in the deep groundwater consistent with the variable conditions observed at SLAPS. The average specific conductivity, chloride, iron, and sulfate content measured in the nested wells at the Facility is presented in Table 2-54.

Radio-isotope dating using tritium analysis of the groundwater from the shallow and deep zones was conducted at SLAPS. Tritium is a hydrogen-3 isotope with a half-life of 12.3 years. It is produced in atmosphere by natural radiation and is brought to the earth's surface by precipitation. Additional tritium was introduced into the atmosphere during nuclear weapons testing in the 1950s and 1960s. Sufficient tritium was added to the global water cycle so as to make pre-1950 water distinguishable from post-1950 water. Higher concentrations of tritium are indicative of relatively young water that has not had the time to allow for tritium decay. Lower concentrations of tritium are indicative of relatively older water that has undergone longer residence times, greater amounts of tritium decay, and has not received tritium from man-made sources (Hem, 1970). At SLAPS, an order of magnitude or more difference in tritium concentrations exist between upper zone groundwater samples and lower zone groundwater samples. These results indicate that groundwater in the upper zone is recent (less than

50 years old) and the groundwater in the lower zone is older (at least 50 years). Water recharge to the upper zone is evidenced by these data. The different shallow and deep tritium concentrations also suggest no or limited hydraulic communications between the zones, otherwise more uniform concentrations would exist (by groundwater mixing between zones) (SAIC, 1998a).

2.7.3.2 Deep Groundwater Zone

The deep groundwater zone at the Facility includes the low permeability clay (aquitard) that separates the deep and shallow groundwater zones and the underlying silty clay and basal sands/gravels. These intervals correlate with SLAPS HZ-B (low permeability clay), and HZ-C (underlying silty clay and basal sands/gravels). The lithology within a few feet of the top of the bedrock is highly variable with most areas having tight clay with gravel within the clay matrix. A few areas had a more permeable sand/gravel zone above bedrock. Given the limited occurrence (two borings) of sand/gravel above bedrock, these permeable zones are not considered interconnected, but instead constitute hydraulically isolated beds (refer to hydrology, Section 2.8).

At SLAPS, the deep groundwater was characterized by "remarkably uniform chemical character" (USACE, 2003), with alkalinity as one of the dominant components. The deep groundwater had lower levels of calcium, potassium, sodium, magnesium, and iron. Sulfate and chloride were present at only very low concentrations (USACE, 1998). The deep groundwater zone also had significantly lower tritium levels indicating groundwater older than 50 years (USACE, 1998).

As stated above, the shallow and deep groundwater zones are considered hydrologically separate, with low or negligible communication between the zones. This is supported by the following information:

- The laboratory and field measurements of hydraulic conductivity confirm a low permeability clay that separates the two groundwater zones.
- At SLAPS, the groundwater geochemistry and tritium levels are significantly different for the shallow and deep groundwater.
- At the Facility, the groundwater geochemistry demonstrated similar differences as observed at SLAPS site between the shallow and deep zones.
- Potentiometric groundwater levels are significantly different in the shallow and deep groundwater zones.
- The occurrence and distribution of potential chemicals of concern (PCOCs) is significantly different in the shallow and deep groundwater zones.

It should be noted that research has shown that pure, reagent grade organic chemicals such as solvents can cause large increases in hydraulic conductivity (Green et al., 1981, Brown et al., 1983, 1984). However, further studies have indicated that the solvents heptane and TCE at

concentrations equal to their solubility limits in water had no effect on hydraulic conductivity (Bowders and Daniel, 1987). Additionally, when samples are maintained under a vertical confining stress of 160 kilopascals (kPa) the hydraulic conductivity was unaffected (Quigley and Fernandez, 1989, Huecker, 1992). This indicates that hydraulic conductivity in soil located deeper than approximately 30 feet below the ground surface (bgs) would not be affected by free phase solvents.

2.8 Hydrology

In order to assess groundwater movement within a porous medium, it is important to understand the relationship between various groundwater parameters within the groundwater system. This includes hydraulic conductivity (K), horizontal hydraulic gradient (i), effective porosity (n), and linear groundwater velocity (V). In order to calculate groundwater velocity, the K , i , and n parameters are needed.

Hydraulic Conductivity

Hydraulic conductivity is defined as a measure of the capacity for a porous medium to transmit water (Driscoll, 1986). The K value for a given medium is a function of the porous medium as well as the fluid flowing through it. Hydraulic conductivity can be determined through a number of field tests such as slug and pump tests and laboratory tests such as falling or constant head parameter tests. The units for hydraulic conductivity are length per time (typically centimeters per second (cm/sec)).

Transmissivity

Transmissivity is defined as a measure of the hydraulic conductivities through the thickness of the media. For an unconfined aquifer, the media thickness is the saturated thickness of the aquifer or the height of the water table above the top of the underlying aquitard that bounds the aquifer (Freeze and Cherry, 1979). The units for transmissivity are length squared per time [typically centimeters squared per second (cm^2/sec)].

Horizontal Hydraulic Gradient

The horizontal hydraulic gradient refers to the horizontal slope of the groundwater table within the same hydrologic unit. For instance, assume two wells (A and B) within the shallow zone are located 100 feet apart and the groundwater elevation is 401 feet at well A and 400 feet at well B. Then the slope (gradient) of the water table between the two wells can be obtained by dividing the distance between wells A and B by the difference in groundwater elevation [i.e., $1/100 = 0.01$ feet per foot (ft/ft)]. A value of 0.01 ft/ft indicates that the groundwater table elevation changes 0.01 feet for every 1 foot of horizontal distance. The horizontal hydraulic gradient is required in calculating the groundwater flow velocity through the aquifer. With all other parameters equal, the steeper the gradient, the faster the flow.

Effective Porosity

Effective porosity, also known as specific yield in unconfined flow systems, is a measure of the system's ability to release water from storage. Effective porosity should not be confused with total porosity. Total porosity is the available pore space or voids between the individual soil grains. Effective porosity is a measure of the ability of the water contained in those voids to be released. For instance, the total porosity of a clay can be between 40 and 70 percent. However, the effective porosity of clay is generally between 0 and 10 percent (Freeze and Cherry, 1979). This is due to soil surface retention of water and dead-end pore space. On the other hand, sand and gravel total porosities are generally similar to their effective porosities because of lower surface retention. The lower surface retention allows water to move more freely between the pores. The effective porosity for the shallow groundwater zone at the Facility (a silty clay) is estimated at 10 percent based on the literature values.

Linear Groundwater Velocity

Linear groundwater velocity is defined as the ratio of travel distance to travel time. The parameters of K , i , and n are required. Linear groundwater velocity can be expressed by the following equation:

$$V = \frac{Ki}{n}$$

where: V = linear (horizontal) groundwater velocity
 K = hydraulic conductivity
 i = horizontal hydraulic gradient
 n = effective porosity (0.10)

2.8.1 Groundwater Elevations **Shallow Groundwater Zone**

Groundwater elevations have typically been recorded quarterly at the Facility. Appendix B contains a summary of quarterly water level measurements for August 2000 through June 2003. These elevations were used to construct groundwater elevation isopleth maps for the shallow groundwater zone using a Kriging estimation procedure computer program (Surfer®). Groundwater elevation isopleth maps for the shallow groundwater zone for the last four quarters (August 2002, December 2002, March 2003, and June 2003) are presented in Figures 2-123 through 2-156, respectively. The lowest median water table elevations were observed during the third quarter (August 2002) and the highest median water table elevations were observed during the second quarter (June 2002).

The groundwater isopleth maps indicate a consistent groundwater flow direction to the east towards Coldwater Creek. This is consistent with SLAPS data that show shallow groundwater flowing towards Coldwater Creek.

In order to determine velocities, the horizontal groundwater gradient was calculated at several areas across the facility. A summary of the shallow groundwater horizontal gradients is

presented in Table 2-56. The horizontal gradients ranged from 0.007 ft/ft to 0.015 ft/ft with a site-wide average of 0.01 ft/ft. The horizontal gradient of 0.01 ft/ft is used in subsequent velocity calculations (see Section 2.8.3).

Deep Groundwater Zone

The groundwater potentiometric elevations obtained from the deep groundwater monitoring wells are presented in Figure 2-167 (June 23, 2003) and Figure 2-178 (August 12, 2003). The deep monitoring wells from both the Boeing and SLAPS are included to better understand regional trends in groundwater flow directions. The groundwater potentiometric elevations vary considerably across the Facility and SLAPS and indicate that the deep groundwater zone is not a continuous or well defined hydrologic unit. Although the deep groundwater is within a confined groundwater zone and not directly hydraulically connected to Coldwater Creek, the deep groundwater is expected to flow to the northeast down the Coldwater Creek valley.

The "irregular" deep groundwater potentiometric elevations are likely due to variations in lithology and confinement of the intervals screened.

The deep groundwater zone is neither homogeneous or isotropic. The "potentiometric head" is influenced by the hydraulic conductivity, confinement pressure, and variations in these parameters across the site. In some areas the deep groundwater wells or piezometers are screened in low permeability clay, and have a low potentiometric surface due to the low ability of this interval to produce water (i.e., low K value). In one well (MW9D), the deep groundwater piezometer screened an apparently high permeability sand/gravel interval, which has a high potentiometric surface (approximately two feet above the ground surface, i.e. artesian) due to the greater ability of this interval to produce water (i.e., high K values and confining pressure).

The following is taken from Freeze and Cherry (1979) concerning the interpretation of potentiometric surfaces:

The concept of a potentiometric surface is only rigorously valid for horizontal flow in horizontal aquifers. The condition of horizontal flow is met only in aquifers with hydraulic conductivities that are much higher than those in the associated confining beds. Some hydrogeological reports contain potentiometric surface maps based on water level data from sets of wells that bottom near the same elevation but that are not associated with a specific well-defined confined aquifer. This type of potentiometric surface is essentially a map of hydraulic head contours on a two-dimensional horizontal cross section taken through the three-dimensional hydraulic head pattern that exists in the subsurface in that area. If there are vertical components of flow, as there usually are, calculations and interpretations based on this type of potentiometric surface can be grossly misleading.

Therefore, the deep groundwater potentiometric surface elevations are not utilized to calculate groundwater gradients or velocities because the deep groundwater elevations are obtained from dissimilar lithologies and do not represent a continuous, interconnected, hydrologic unit.

Deep and shallow groundwater elevations for well pairs are presented in Figures 2-17 and 2-18. Vertical hydraulic gradients can be calculated for these well pairs in a manner similar to the calculation of horizontal groundwater gradients. If the deep groundwater zone is confined or a hydraulic barrier is present between the shallow and deep zones, the pressure in the deeper zone could be higher than the shallower zone. The higher pressure would result in a higher groundwater elevation in the deep zone well because the well acts as a pressure relief point. The vertical gradient calculated under this scenario, would indicate an upward groundwater flow direction. The gradient direction indicates the potential for groundwater flow in that direction. However, the actual flow direction is also governed by the permeability of the porous media and by the hydrogeology (confining units, etc.). Therefore, the calculated vertical hydraulic gradient may not predict actual flow in an anisotropic and heterogeneous aquifer (such as exists in the deep zone).

The vertical gradient is calculated by dividing the difference in elevation of the groundwater surfaces by the difference in length between well intakes. For example, during the second quarter of 2003 the groundwater elevation in MW9S was 6.52 feet lower than MW9D. The intake (top of the well screen) of MW9S is at an elevation of 528.17 msl, the intake for MW9D is 477.25 msl. The difference between intake points is 50.92 feet. To calculate the vertical gradient the difference in elevation is divided by the difference in length $[-6.52 \div 50.92 = -0.128$ feet/foot (ft/ft)]. The resulting value indicates that the groundwater elevation in MW9S increases 0.128 feet for every foot in which the length between the intake point decreases. Theoretically, as the difference between intake points approaches zero, the groundwater elevations in both wells would approach identical values. The above example indicates an upward vertical gradient because the difference in groundwater elevations is negative.

The calculated vertical gradients for the second and third quarters of 2003 are presented in Table 2-7. Deep groundwater elevation was higher than the shallow groundwater elevation, indicating an upward vertical gradient for the MW5A, MW8A, MW6, and MW9 well nests at the Facility and the B53W01, B53W02, B53W03, B53W04, B53W05, B53W06, B53W07, B53W08, M10-8, and M10-25 well nests at SLAPS. Downward gradients were calculated for the MW-11 and MW10 well nests at the Facility and the M10-15 well nest at SLAPS.

2.8.2 Hydraulic Conductivity

Numerous laboratory and field tests to determine the hydraulic conductivity of the unconsolidated materials have been conducted at the Facility as part of the RFI and during earlier investigations at the Facility. Similar tests have also been conducted at the nearby SLAPS. These tests included:

- Laboratory tests (Triaxial);
- Field slug tests; and
- Field pump tests

Geotechnical Laboratory Analysis

Eight soil samples were collected during the RFI investigations at the Facility, five from the North Tract and three from the South Tract. Vertical hydraulic conductivity analysis was conducted by laboratory method D-5084 on the eight samples, the results ranged from 3.1×10^{-4} cm/sec for the organic silt to 1.1×10^{-9} cm/sec for a predominately clay sample collected at a depth of 60 feet below ground surface (bgs). These laboratory results indicate that vertical hydraulic conductivity decreases with depth. Moisture content ranged from 18.5 percent to 30.1 percent and generally decreased with depth.

A summary of the results of the geotechnical analysis is presented in Table 2-67. Copies of the geotechnical laboratory reports are included in Appendix BC.

Pump Test

Two short-term pump tests were conducted as part of the RFI in November 2001 on a well (MW-7S) at the location of SWMU 17 on the South Tract (Harding ESE, 2002a). The drawdown data for the pumping well and three nearby piezometers were graphed and analyzed using the Neuman method (Neuman, 1975) to determine the hydrogeologic parameters of transmissivity and horizontal hydraulic conductivity for the shallow groundwater zone. At SWMU 17, the saturated thickness was estimated to be about 17 feet (distance from the top of the silt layer to the top of the static water level in MW-7S prior to starting the pump test). A summary of calculated hydraulic conductivity and transmissivity values are presented in Table 2-78.

Calculated transmissivity values ranged from 1.17×10^{-1} cm²/sec (monitoring well MW-7S) to 4.89×10^{-3} cm/sec (piezometer TP-1). Calculated horizontal hydraulic conductivity values ranged from 2.21×10^{-4} cm/sec (monitoring well MW-7S) to 9.32×10^{-6} cm/sec (piezometer TP-1).

The hydraulic conductivity of 2.4×10^{-4} cm/sec for MW-7S is consistent with the reference values for a silt while the hydraulic conductivity range of 8.8×10^{-5} to 9.3×10^{-6} cm/sec for the piezometers is consistent with the reference values for a glacial till/silty clay (Freeze and Cherry/Fetter, 1979/1994).

It should be noted that the MW-7S was able to be pumped at a flow rate of 1.2 liters per minute with only 1.8 feet of drawdown over an 7.1-hour test. Given the low flow characteristics observed in the shallow monitoring wells at the Facility except for MW-7S, the overall hydraulic conductivity for the site is estimated as closer to the values calculated from slug tests conducted at the site (1×10^{-5} to 1×10^{-6} cm/sec) (see below). The pumping rate of liter per minute with only a few feet of drawdown at MW-7S was not observed elsewhere on site during groundwater sampling and, therefore, not considered typical for the shallow groundwater zone. A possible explanation for the higher achievable pumping rate and calculated hydraulic conductivity is granular fill that may exist around a subsurface structure located at the southeast corner of Building 51, approximately 25 feet from MW-7S. This subsurface structure was part of the maskant application operation and was 15 feet long by 12 feet wide and approximately 18 feet bgs.

Slug Tests

Field permeability slug tests were conducted at the Facility by Burns & McDonnell (1989) and ATEC (1990). Burns & McDonnell conducted baildown slug tests in 1989 on six shallow monitoring wells at the Facility. Results of these tests were evaluated using the Papadopoulos, Bredehoeft and Cooper (1973) method. Calculated transmissivity values ranged from 1.3×10^{-2} cm²/sec to 9.9×10^{-3} cm²/sec, hydraulic conductivity values ranged from 2.1×10^{-5} cm/sec to 6.1×10^{-6} cm/sec.

ATEC conducted baildown slug tests on three shallow monitoring wells at the Facility in 1990. Results of these tests were evaluated using the Hvorslev Water Level Recovery Method as described by Freeze and Cherry-Cherry (1979). Calculated hydraulic conductivity values ranges from 1.38×10^{-5} cm/sec to 9.14×10^{-6} cm/sec. Results of the slug tests are summarized in Table 2-78.

SLAP Site Data

Numerous slug tests, triaxial laboratory tests, and packer tests were conducted to characterize the unconsolidated materials at SLAPS. A summary of the hydraulic conductivity data for the FUSRAP North County Site (SLAPS and HISS) is presented in Table 2-89. The geometric mean hydraulic conductivity for the shallow silty clay unit at the North County site was 1.2×10^{-5} cm/sec (USACE, 2003). The geometric mean hydraulic conductivity for the bedrock was 2.9×10^{-6} cm/sec.

Summary

Based upon the various studies conducted at the Facility, the average-geometric mean hydraulic conductivity for the shallow groundwater zone is $6.893.83 \times 10^{-5}$ cm/sec. This is very similar to the geometric mean hydraulic conductivity value obtained for the North County site (1.2×10^{-5} cm/sec).

2.8.3 Groundwater Velocity

The horizontal groundwater velocity in the shallow zone at the Facility can be calculated using the following values:

- Effective porosity (n) of 10 percent (literature value);
- Average facility-wide horizontal hydraulic gradient (i) of 0.0107 ft/ft; and
- Average facility-wide hydraulic conductivity (K) of $6.893.83 \times 10^{-5}$ cm/sec.

Using the equation $V = Ki/n$, the average linear groundwater velocity at the Facility is 7.64.2 feet per year.

2.9 Surface Water – Coldwater Creek

The following discussion concerning Coldwater Creek has been modified from USACE (2003). Coldwater Creek is the main drainage for the area which includes the Airport, the Boeing facility and SLAPS. Coldwater Creek (Creek), which originates south of the Airport, generally flows north between the cities of Overland and Florissant and then east to the Missouri River, emptying into the Missouri River at River Mile 7 (Creek Mile 0). The Creek is contained in culverts beneath the Airport and the southeastern corner of the Facility, daylighting at Banshee Road. The open Creek marks the eastern property boundary between the Facility and SLAPS.

The Creek and tributaries are shown in Figure 2-189 along with the USACE designation of segments of the creek for discussion purposes, Reaches A, B, and C.

The main channel of Coldwater Creek is 19.5 miles long and has relatively short tributary streams. At McDonnell Boulevard, the drainage area is 12 square miles (USACE, 2003). The total watershed area of Coldwater Creek is 47 square miles. The annual average flow rate of Coldwater Creek (SAIC, 1993) is 41 cubic feet per second or equivalent to 65 million gallons per day (gpd). The USGS maintained a stream gauge in Coldwater Creek at McDonnell Boulevard Bridge and collected streamflow data from August 1996 through September 1997 and August 1998 through September 2001. The peakflow measured during this timeframe was 2,790 cubic feet per second (cfs), the monthly streamflow averages ranged from 4.7 cfs in December to 21.8 cfs in February. The average annual streamflow was approximately 11 cfs.

Flooding in Coldwater Creek occurs annually. Most of the flooding results from short-term, high-intensity thunderstorms that cause flash floods. Coldwater Creek is the recipient of surface water/storm water drainage from the Airport, the Boeing Facility, SLAPS, and numerous other commercial and industrial facilities.

Coldwater Creek is designated as a metropolitan no-discharge stream except for permitted discharges and non-contaminated storm water flows. Coldwater Creek from its mouth at the Missouri River upstream 5.5 miles to its crossing with US Highway 67 (Lindbergh Boulevard) [USACE Reach C on Figure 2-189] is classified by MDNR as a Class "C" waterway meaning that there are periods of no flow in the Creek, but permanent pools are always present. The

upstream portion of the Creek between the Airport and Highway 67, which includes the Facility and SLAPS, is an unclassified water of the state.

The highest point in the watershed is located at the headwaters near Overland located approximately 4 miles southwest of Boeing/SLAPS. The lowest point is located where Coldwater Creek discharges into the Missouri River, approximately 15 miles northeast of the Boeing/SLAPS property. The lowest elevation of the Creek in the section adjacent to SLAP and the Facility (between Banshee Road and McDonnell Boulevard) is 505 feet msl (Hempfen, 2003).

The Creek is the primary surface-water feature in the area but is not used for municipal drinking water. The closest municipal water intakes are located on the Mississippi River approximately 5 miles downstream of where the Missouri River discharges into the Mississippi River (BNI, 1992), or 12 miles from the mouth of Coldwater Creek.

The water quality in Coldwater Creek is generally poor. Studies of aquatic life (USACE, 2001) indicate that the stream ecology is severely impacted. The nature of pollution causing this impact is not definitively known but is believed to result from storm water from commercial and industrial facilities, residential areas, and the Airport. More than a dozen facilities that are permitted under the National Pollutant Elimination System (NPDES) program discharge directly into the stream, including Ford Motor Company, Lambert-St. Louis International Airport, and Boeing. These discharges include storm water runoff, cooling water discharge, water treatment, and airport and road deicing.

Surface water and sediment have been collected from Coldwater Creek for the USACE since 1997 as part of the environmental monitoring plan for the FUSRAP. The environmental monitoring of Coldwater Creek focuses on the evaluation of radium isotopes, thorium isotopes, uranium isotopes, inorganic and organic chemicals, metals, and certain general water quality parameters such as dissolved oxygen, pH, and turbidity. The monitoring is conducted to ensure compliance with environmental regulations and to assess whether runoff from SLAPS and HISS sites contribute to contamination of surface water and sediment in the Coldwater Creek.

Additionally, a study of the Creek was conducted by the USGS in 1997 with the following objectives:

- Determine if Coldwater Creek is a gaining or losing stream in the vicinity of SLAPS;
- Determine the concentrations of chemical constituents in Coldwater Creek upstream and downstream from SLAPS; and
- Determine the physical, mineral, and chemical composition of stream bed sediments in Coldwater Creek upstream and downstream from SLAPS.

One of the findings of this study was "Results of the various seepage runs indicate that no measurable quantity of diffuse groundwater inflow could be detected along Coldwater Creek in the vicinity of SLAPS" (USGS, 1998). The minimum quantity of inflow that could be measured was about 0.1 to 0.2 cfs.

The results of sediment and surface water sampling conducted by the USGS and USACE were evaluated in the *Ecological Risk Assessment for the North County Site* (USACE, 2001) and the *Feasibility Study for the North County Site* (USACE, 2003). No surface water contaminants of concern were identified. The sediment potential carcinogenic risks and hazard index (HI) results for non-radiological contaminants detected in sediment indicate that one metal (arsenic) and five organics—polynuclear aromatic hydrocarbons (PAHs) [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene, and indeno(1,2,3-cd-pyrene)] exceeded risk criteria. Arsenic levels, however, were below background in Coldwater Creek adjacent to SLAPS and the Facility (USACE Reach A on Figure 2-189). Additionally, none of the five organics—PAHs were identified above risk criteria in this section of the Creek (USACE Reach A, between Banshee Road and Interstate 270).

PAHs constitute a diverse class of compounds that are formed during the incomplete burning of organic substances such as coal, oil and gas. PAHs tend to be elevated in nonbiological materials within urban industrial areas (Eisler, 1987). These compounds are found in the air attached to dust particles and are emitted from vehicle exhausts, asphalt roads, and furnaces burning wood or coal. Most of the PAHs released to the atmosphere eventually reach the soil by direct deposition or deposition on vegetation. Therefore, the Baseline Risk Assessment for SLAPS concluded that concentrations determined at SLAPS (including Coldwater Creek sediments) might not be exceptional for the area or have originated from past operations at SLAPS (Argonne, 1993).

The Feasibility Study (FS) concluded that remediation of sediment in Coldwater Creek, including the section adjacent to the Facility, was merited based on radionuclide exposure under a residential scenario. The FS presented six remedial alternatives for the North County Sites (including SLAPS and Coldwater Creek). The recommended alternative includes dredging Coldwater Creek sediments below the mean water gradient in the creek and subsequent disposal.

3.0 Investigation Methods and Objectives

3.1 Sampling and Analysis Methodology

This section describes the sample collection, monitoring well installation, and laboratory analysis procedures and methodology.

3.1.1 Direct Push Sampling Technology

Soil Sampling

Direct push/hydraulic soil probe (Geoprobe) subsurface sampling equipment was utilized as the primary drilling methodology wherever site conditions permit its use. Geoprobe equipment was mounted on a truck or all terrain vehicle (ATV) for subsurface investigations. Approximately 207 shallow soil borings and 10 soil borings to the top of bedrock were installed as part of this RFI investigation between February 1998 and July 2003. Temporary piezometers were installed in 172 of the shallow borings and eight of the deep borings to allow for the collection of groundwater samples. Nine shallow borings and two deep borings were completed as permanent piezometers to allow for collection of groundwater samples over time.

The hydraulic soil probe technology utilizes static and percussion forces to drive probing and sampling tools into the subsurface. A 2-inch diameter, three to five foot long stainless steel soil sampling tube (Geoprobe Macro-Core®) was lined with a new, disposable polybutylate (acetate) liner and driven to the desired sampling depth by steel probing rods. The sampling tube was withdrawn from the boring and opened and the polybutylate-encased sample was removed from the sampling tube. Each sample liner was cut opened and immediately scanned with a photoionization detector (PID) to identify potential presence of volatile organic compounds (VOCs). To maintain lithographic descriptive consistency, soil samples were described and classified in accordance with the Unified Soil Classification System (USCS), and a soil boring log was completed for each boring. Copies of the soil boring logs for the RFI borings are included in Appendix GD.

Geoprobe Dual-Tube® sampling equipment was used to evaluate deep soil and groundwater conditions for ten locations beneath the shallow water-bearing unit at the Facility (Study Areas E and F). This equipment was also used to evaluate soil and groundwater between 20 and 25 feet bgs beneath the organic silt at three locations in Study Area Division C(3). The dual-tube sampler was used to eliminate potential cross-contamination between the shallow water-bearing unit and the underlying clay unit. Two sets of probe rods were used to collect continuous soil samples as follows:

1. The outer set of 2.125-inch outside diameter (OD) rods was initially driven into the ground as a protective casing. These rods provide a sealed hole that eliminates the

potential of any side slough and enables the collection of soil samples across a perched water table.

2. The second smaller set of 1.0-inch OD rods were then placed inside of the outer casing. The smaller rods hold a sample liner in place as the outer casing is driven one sampling interval.
3. The smaller rods were then retracted to collect the soil sample from the filled liner.

An aliquot of sample was placed directly into the appropriate sample container from each sampling location. No compositing of samples was performed. The samples collected for VOCs analysis were filled to the top of the jar to minimize the amount of headspace in the jar which could result in the loss of volatile compounds from the sample. Samples collected for organic analysis were immediately placed into an iced sample cooler to prevent the loss of volatile compounds. Soil samples acquired for metals analysis were collected by placing an aliquot of soil into an appropriate glass sample container.

To prevent cross-contamination between samples, disposable nitrile gloves were worn by the field geologist during the collection of the samples. The sampler donned a new pair of disposable gloves before collecting each sample. The sampling devices were decontaminated using an Alconox® or Liquinox® soap wash and potable water rinse prior to each use.

Following completion, each soil boring was grouted with a bentonite slurry that was tremied to the bottom of the boring or filled with granular bentonite chips in compliance with MDNR well program guidelines. The surface asphalt or concrete at each boring location was repaired. Portable roll-off containers or drums were used to accumulate soil cuttings for subsequent transfer into larger roll-off units and management by Boeing. Decontamination liquids were disposed of at the IWTP.

Temporary Piezometer Groundwater Sampling

Due to the slow recharges of shallow groundwater at many locations across the Facility, temporary piezometers were used to collect groundwater samples from the shallow soil borings. Each temporary piezometer was constructed of 1-inch diameter polyvinyl chloride (PVC) with flush-threaded joints. Three to 10 feet of slotted screen was utilized at the bottom of each installation. Each temporary piezometer was installed to an approximate completion depth of 12 to 20 feet bgs. Areas along the eastern portion of the Facility required slightly deeper completion depths.

If groundwater sampling was conducted within approximately 30 minutes of the boring completion, the temporary piezometer was sampled using a disposable polyethylene mini-bailer without purging. Otherwise, each temporary piezometer was purged using a mini-bailer. Due to the limited availability of groundwater, each temporary piezometer was purged by removing one

well casing volume of groundwater. Upon completion of the purging process, groundwater samples were collected using a dedicated mini-bailer.

3.1.2 Permanent Piezometer Installation Procedures

Shallow Permanent Piezometers

Ten shallow piezometers were installed in direct push borings. Piezometers TP-1, TP-2, TP-3, TP-4, TP-5, and TP-6 consisted of 6 to 10 feet of 1-inch diameter 0.010-inch slotted PVC well screen and 1-inch PVC riser. Rounded, silica sand was gravity placed to a height of approximately two feet above the top of the screen with a bentonite chip seal placed above the sand to approximately one foot bgs. Surface completion consisted of a watertight flush mount well box with a one-foot steel skirt set into concrete.

Piezometers B48N1, B27W3D, RC6D, and RC8D were installed through the dual-tube probe rods and consisted of 5 or 10 feet of pre-pack well screen. The well screen consisted of dual 0.010-inch slotted PVC well screen with the annulus filled with rounded, silica sand. The inner well screen has a diameter of 0.5 inches internal diameter (ID). Rounded, silica sand was gravity placed to a height of approximately one foot above the top of the screen with a bentonite chip seal placed above the sand to approximately one foot bgs. Surface completion consisted of a watertight flush mount well box with a one-foot steel skirt set into concrete.

Deep Permanent Piezometers

Two deep piezometers were installed in Study Area Division E(5). Probe rods (2.125-inch OD) with an expendable drive point were driven to refusal on bedrock (between 68 and 69 feet bgs). Soil samples were not collected.

Pre-pack well screen, 1.4 inches OD (0.75 inches ID) was lowered into the probe rod string with threaded PVC riser pipe (0.75 inches ID). The pre-pack well screen has an inner factory-slotted PVC screen with 0.010 in. slots. An outer screen constructed of stainless steel wire cloth retains the filter media in place and provide strength to the assembly as the screen is installed to construct the monitoring well.

Once the well assembly was lowered to the bottom of the probe rod string, the probe rods were retracted to approximately 10 feet above the screen. A sand barrier to prevent grout from entering the screen consisting of rounded, fine-grade sand was gravity fed through the rod annulus and measured using a weighted measuring tape to approximately 5 feet above the well screen. With the barrier in place, bentonite slurry was pumped into the annulus using a tremie tube as the outer rods were retracted. Surface completion consisted of a watertight flush mount well box with a one-foot steel skirt set into concrete.

3.1.3 Monitoring Well Installation Procedures

A total of 23 shallow monitoring wells were installed between April 1998 and June 2002 as part of the RFI investigation (one of which has been permanently closed due to construction). Additionally, a total of nine monitoring wells were installed as part of the RFI to monitor the deep groundwater zone. In addition to these 32 monitoring wells, at least 47 additional shallow wells have been installed at the Facility (17 of which have been closed). Monitoring well logs for the RFI installed monitoring wells are included in Appendix G. Table 3-1 presents a list of wells along with construction data for the monitoring wells installed at the Facility for this and previous investigations.

Monitoring wells were installed in accordance with standard hollow-stem auger (HSA) drilling methods using 8.25-inch outside diameter, 4.25-inch ID hollow-stem augers. Prior to drilling at the initial and all subsequent borings, ancillary rig equipment was cleaned using a high pressure cleaner wash at the temporary on-site decontamination station to eliminate cross-contamination between successive drilling locations.

During the monitoring well installation process, soil samples were collected at select locations/ intervals for field screening, lithographic description, and potential chemical analysis. Soil samples were collected using either a Lasky (5-foot by 4-inch) core barrel or a split spoon (2-foot by 2-inch) sampler. Each sampler was opened and immediately scanned with a PID to identify potential presence of VOCs. To maintain lithographic descriptive consistency, soil samples were described and classified in accordance with USCS.

Each monitoring well was installed in accordance with the following general protocols:

1. Each monitoring well was constructed of 2-inch diameter PVC with flush-threaded joints. Ten-foot screen length sections (0.010-inch slot) were typically installed within each well.
2. The artificial sand pack consisted of chemically inert, rounded, silica sand and was placed to a height of approximately 2 feet above the top of the screen.
3. A 3-foot thick bentonite pellet seal was placed above the sand pack material.
4. The annular space above the bentonite pellet seal was sealed with cement/bentonite grout.
5. Each monitoring well was completed with a flush-mounted, water-tight protective casing.
6. Well construction details were recorded on standard field forms.

Special installation procedures were utilized for wells screened in the deep groundwater zone to ensure that cross-contamination does not occur between the shallow and deep saturated units. Six wells were installed to the bedrock surface between 70 and 80 feet bgs and three were installed within the center of the deep groundwater zone at a total depth of 40 to 45 feet bgs. Deep wells were constructed by using 10.25-inch ID hollow stem augers to set a 10-inch casing

at an approximate depth of 25 feet bgs for the intermediate wells and 50 ft bgs for the deep wells. The casing was grouted from the bottom of the casing to ground level by filling the borehole with grout as the HSA were removed. The casing was capped with a PVC cap and filled with potable water as it was lowered into the grouted borehole. After the grout set, the water was pumped out of the casing and the boring was advanced through the casing to the total depth using 4.25-inch ID hollow stem augers. Casing was constructed of schedule 40 PVC for the intermediate wells and steel for the deep wells.

After installation, monitoring wells were developed to ensure that particulate matter introduced into the formation from the drilling process was removed, and to ensure good hydraulic connection with the formation. Formation water and fines were evacuated throughout the water column. A bailer or submersible pump was moved up and down throughout the water column in the screened portion of the well to maximize water flow through the entire screened length.

Development procedures were continued until one of the following criteria was met:

- Removal of a minimum of three well casing volumes or until the well is dry; or
- Stabilized measurements of pH, temperature, and specific conductance are recorded (e.g. consecutive field readings within 10 percent of each other).

3.1.4 Field Screening and Sample Selection Procedures

Soil sample were screened in the field with a PID for total organic vapors (TOV) by the headspace method. This involved placing a portion of the soil sample into a resealable plastic bag or similar container and allowing time for volatilization, if any, to occur. The concentration of VOCs that partition from the soil to the gaseous state are then recorded in parts per million (ppm) by placing the PID probe into the container headspace.

The PID was calibrated at a minimum of once per day during the field investigation effort. Instrument calibration was performed in accordance with the manufacturers' recommended procedures using either commercially available or laboratory-provided calibration standards. Calibration data was recorded in the Field Logbook.

3.1.5 Sample Collection Procedures

Samples were collected and submitted for selective on-site chemical analysis of VOCs, total petroleum hydrocarbons (TPHs), and/or metals. The selection of proposed analytical parameters is based upon prior investigation results and knowledge of chemical usage for each specific area of concern.

Soil Sampling

Soil samples were collected from selected borings/intervals for lab analysis using the 4-foot Macro-Core Geoprobe sampler, Lasky core barrel, or split spoon sampler. When coarse gravel fill material was encountered below the concrete and collection of sufficient soil volume is not possible, the borings were advanced until finer-grained materials (e.g., sand, silt or clay) were encountered, and the sample then collected.

The results of the field screening (PID, visual observation) were utilized in the selection of sample intervals. The sample with the highest TOV level was submitted for chemical analysis. Visual observations by the field geologist were also considered in the sample selection process.

Groundwater Sampling

Water level measurements were collected using an electronic water level probe and measured to the nearest 1/100 foot. Data were recorded on standard monitoring forms.

Prior to the collection of groundwater samples, each or monitoring well/permanent piezometer were purged using a downhole submersible pump, a peristaltic pump, or a disposable polyethylene bailer.

Most shallow wells and piezometers were purged and sampled using a dedicated, disposable polyethylene bailer and dedicated bailing twine. Three well casing/sand pack volumes were purged prior to sampling. Field parameters [temperature, pH, specific conductivity (SC)] were collected from a measuring container during the purging process.

Selected shallow wells that were being evaluated for natural attenuation parameters were purged and sampled using a peristaltic pump to allow for accurate measurement of field parameters. Additionally, the intermediate and deep wells were equipped with dedicated bladder pumps to facilitate quarterly groundwater sampling. Wells sampled by pumping were purged in general accordance with EPA Region 1 Low Stress (Low Flow) Purging and Sampling Procedure. Groundwater was purged at a rate that prevented the continued drawdown of the well. During the purge phase field parameters [temperature, pH, dissolved oxygen (DO), SC, redox potential (ORP), and ferrous iron (Fe^{2+}) concentration] were collected at 3- to 5-minute intervals using appropriate calibrated meters installed in a flow-through cell. Sampling was conducted after three successive water level measurements stabilized and the following criteria were met:

- Temperature within 3 percent,
- pH within 0.1 standard unit,
- SC within 3 percent,
- DO within 10 percent, and
- ORP within 10 millivolts.

Although purge volume is not of concern in the low stress (low flow) sampling procedure, a minimum volume at or greater than the total volume of the pump and hose was purged in order to remove any trapped (stagnant) water remaining in the dedicated tubing from previous sampling events. If stability in water level could not be achieved or if the water level fell below the top of the screened interval then the low flow sampling procedure was stopped and the well was purged by removing three well casing/sand pack volumes.

If a well bailed or pumped "dry", the purging process was stopped and the well was allowed to recover. The recovered water was sampled immediately if the recovery rate was slow and a considerable delay would have been needed to purge the entire three well volumes. However, if recovery was moderately fast and the anticipated delay short, then the purging process was resumed until three well volumes were purged.

The following collection procedures were observed when using a bailer to sample a groundwater monitoring well/piezometer:

- The bailer was lowered slowly to the interval from which the sample was collected.
- A determined effort was taken to minimize disturbance of the water column when raising and lowering the bailer in order to prevent aeration of the water column.
- Sample bottles were filled by allowing the water to flow out the valve in the bottom of the bailer and into and along the side of the sample bottle.
- Only bottom-filling high density polyethylene (HDPE) bailers or bailers made of other inert materials were used.
- Only unused or dedicated bailer line was used.

The following constraints were observed when using a peristaltic pump:

- Pumping rate was lowered during sample collection to prevent aeration of the water during sampling.
- Only unused or dedicated sample tubing made of HDPE or other inert materials was used.

The following constraints were observed when using a bladder pump:

- Only pumps constructed of stainless steel or other inert materials were used.
- Only unused or dedicated sample tubing made of HDPE or other inert materials was used.

A summary of the quarterly groundwater field parameter measurements and the sampling protocol is included in Appendix D.

3.1.6 Quality Assurance/Quality Control Samples

In accordance with typical quality assurance protocols, a minimum of one duplicate sample was collected and analyzed per 20 samples (5 percent). The duplicate samples were analyzed for

the same location-specific VOC, TPH, and/or metal parameters as the original field sample. Trip blanks were also utilized to evaluate extraneous VOC impacts for stored groundwater samples.

3.1.7 Sample Management, Preservation, and Chain-of-Custody Procedures

Upon collection, each sample was managed according to the procedures described in this subsection. Appropriate USEPA analytical methods, sample preservation techniques, sample volumes, and holding times were utilized.

Sample Designation

Soil borings installed during the initial RFI conducted in 1998 were designated by "S" the SWMU number that the boring was investigating, "B" and the sequential boring number. For example the second boring installed to investigate SWMU 10 was S10B2. Soil borings installed at SWMU 17 (Study Area D) were labeled "SB-" sequential number (i.e., SB-1).

Soil borings completed during Environmental Field Investigations utilized by the RFI were designated by location and direction from the nearest building. For example, the first soil boring installed east of Building 40 was designated B40E1. The first soil boring installed inside Building 48 was designated B48I1.

Soil samples collected from each boring were identified by probe location and sample depth. For example, the soil sample collected from probe B40E1 at a depth of 6 feet bgs was designated as B40E1-6. Groundwater samples collected from temporary piezometers were designated with a "W" at the end of the boring number (with the exception of SWMU 17 where the temporary piezometers were identified as TP-sequential number). For example a groundwater sample collected from boring B40E1 was designated B40E1W. Deep borings were identified with a "D" at the end of the boring number (i.e., the deep soil boring east of Building 41 was designated B41E1D).

Sample Containers

Samples were collected into sample containers which had been pre-cleaned and assembled to USEPA's Protocol "B". The volume of sample collected and the type of container used was determined by the suggested volumes described in SW-846 for the particular analysis.

Sample Management

Immediately upon collection, each sample was properly labeled to prevent misidentification. The sample labels included the sample number, the sample location, the sample depth, the date sampled, the time sampled, the analyses to be performed, and the sample collector's name. The sample labels were affixed to the sample jar immediately upon collection. The sample labels were made of waterproof material and filled out with waterproof ink.

After labeling, the samples were placed into an appropriate storage container. Samples collected for organic analysis were placed into a storage container with sufficient ice or ice packs to maintain an internal temperature of 4 degrees Celsius (4°C) during transport to the on-site laboratory.

A completed chain-of-custody form was placed in each shipping container to accompany the samples to the laboratory. Any samples submitted for off-site analysis were appropriately packaged in a shipping container to minimize the potential for damage during shipment. The shipping containers were then sealed with several strips of strapping tape.

Samples submitted for off-site analysis were delivered directly to the laboratory (if local) or shipped via overnight courier (such as Federal Express) to the designated off-site laboratory. Samples were shipped so that no more than 24 hours elapsed from the time of shipment to the time the laboratory received the samples. The method of sample shipment was noted on the chain-of-custody forms accompanying the samples. Strict chain-of-custody procedures were maintained during sample handling.

Preservation

Samples for organic analyses were preserved by placing each sample immediately into a cooler with sufficient ice or ice pack material to maintain a temperature of 4°C or less during transport to the laboratory. Sample preservation was not required for soil samples collected for metals analysis. Nitric acid was added to groundwater samples being analyzed for metals. Hydrochloric acid was typically added to groundwater samples collected from monitoring wells but not from temporary piezometers due to the high turbidity of the groundwater samples from temporary piezometers. The turbidity of the samples presented a potential for an effervescent reaction between the acid and the sediment. The laboratory was notified of the preservatives used and adjusted their schedule to meet holding time requirements.

Chain of Custody

A chain-of-custody program was followed to track the possession and handling of individual samples from time of collection through completion of laboratory analysis. Copies of the chain-of-custody record were retained in the permanent file for proper documentation. The chain-of-custody forms include:

- Sample number;
- Date and time of collection;
- Sample type (e.g., soil, groundwater, etc.);
- Parameters requested for analysis;
- Signature of person(s) involved in the chain of possession; and
- Inclusive dates of possession.

3.1.8 Analytical Methods

The samples were submitted to a qualified laboratory for analysis. Sample analyses were conducted for:

- VOCs in accordance with USEPA Method 8260, 8240, or 8021;
- ~~Polynuclear aromatic hydrocarbons (PAHs)~~ in accordance with USEPA Method 8270 or 8310;
- Polychlorinated biphenols (PCBs) in accordance with USEPA Method 8081 or 8082;
- Total and/or dissolved metals in accordance with USEPA Method 6010, 7060, 7421, or 7471;
- TPH by USEPA Method 8015 Modified or OA-1/OA-2, or 3550 Diesel Range Organics (DRO).

Due to the various analytical methods and laboratories utilized for TPH analysis during the RFI process, each of which reported different carbon ranges of TPH, TPH results will be discussed in this RFI Report on the basis of low fraction TPH [referred to as Gasoline Range Organics (GRO)] and high fraction or extractable range TPH (referred to as DRO). The values of TPH GRO and DRO for each sample have been summed into a Total TPH value.

3.1.9 Equipment Decontamination Procedures

Drilling and sampling equipment were decontaminated prior to initial use at the Facility. Decontamination of Geoprobe equipment and other pieces of equipment were performed at the drilling locations. Rinse waters were collected into a bucket or drum.

To prevent possible cross-contamination between samples, down-hole drilling tools and sampling equipment were decontaminated between boring locations. Decontamination procedures for sampling equipment consisted of a wash of an Alconox® or Liquinox® solution, a potable/tap water rinse, followed by a distilled water rinse.

3.1.10 Waste Collection and Disposal Procedures

Waste materials derived from the field investigation, such as drill cuttings, decontamination rinse waters, and personal protective equipment, were accumulated in portable roll-off containers for subsequent transfer into larger roll-off units and management by Boeing. Equipment decontamination rinse waters were transferred to the IWTP where they were treated to meet discharge standards in a similar manner with the chemical process influent. Drums with solid materials remained on-site until proper disposal arrangements were completed by Boeing.

3.1.11 Boring and Monitoring Well Location Survey

All soil borings installed as part of the RFI, with the exception of those inside of buildings and B13E1, B13E2, and B13E3 were surveyed (horizontal and elevation) to Missouri State Plane Coordinates. The locations of borings not surveyed were field measured from building

landmarks (building corners, columns, etc.). All monitoring wells, including RFI and pre-existing wells, were likewise surveyed to Missouri Plane Coordinates.

3.2 RFI Objectives

The objectives of the RFI are to:

- Determine the nature and extent of potential constituents of concern (hazardous materials and petroleum products) that may have been released at the Facility;
- Determine the physical properties (permeability, etc.) of the affected media and the characteristics (flow direction, flow velocity, saturated thickness, etc.) at the Facility; and
- Obtain the necessary data to support the risk assessment (RA) and the Corrective Measures Study (CMS), if needed.

3.2.1 Data Needs and Usage

An investigation to delineate the nature and extent of releases at the Facility required various types and amounts of information. Specific investigation approaches, methodologies, and data were required to facilitate the RFI investigation process. This section of the document summarizes the general strategy used for the collection of the data needed to achieve the RFI objectives.

Based on a review of previous investigations results and an evaluation of Facility-wide conditions, the RFI was conducted to characterize/delineate the nature and extent of any subsurface soil/groundwater impacts. Soil and groundwater sampling locations were selected across the Facility where constituents of concern (COCs) were most likely to be found based on historical knowledge, prior investigation results, hazardous constituents or petroleum managed at the various areas, and field screening criteria (visual observations and portable instrument screening). Selected samples were collected and submitted for laboratory analyses.

In addition, groundwater monitoring activities were conducted for a Facility-wide groundwater monitoring network to determine groundwater flow direction and gradients. Monitoring results were used to evaluate potential migration of impacted groundwater at the Facility.

3.2.2 Data Quality Objectives (DQOs)

The intended use of the various data types was evaluated to establish appropriate data quality objectives (DQOs). A summary of this evaluation is provided below.

As described in the MDNR-approved RFI Work Plan, the following DQO levels were deemed appropriate:

1. DQO Level I was deemed appropriate to conduct screening and acquire data for basic site characterization (e.g., pH, temperature, specific conductance, water level elevations, physical descriptions, PID readings, and other similar geologic/

hydrogeologic information). Specifically, the data acquired under DQO Level I were as follows:

- detect changes in groundwater characteristics,
 - develop groundwater elevation contour maps,
 - evaluate groundwater flow gradients,
 - describe basic physical properties of investigated media, and
 - verify adequate purging of monitoring wells.
2. DQO Level III was deemed appropriate for soil and groundwater sample analyses. The data acquired under DQO Level III was used to characterize constituent concentrations in various media and delineate the nature/extent of any releases of hazardous wastes/constituents. These data may also be used to determine soil/groundwater clean-up objectives, support a risk assessment, and support engineering evaluations necessary to select and design Corrective Measures, if required.

3.2.3 Investigation Threshold Levels (ITLs)

ITLs are commonly developed and used at various investigation sites to determine whether additional field investigations, site-specific risk assessments, and/or remediation efforts are warranted. This concept is inherent to both RCRA Corrective Action and Superfund programs. This concept was determined to be appropriate for the Site and conservative values were developed against which the field investigation data was evaluated.

This section identifies these conservative ITLs values that were used to determine the need for further evaluation or to recommend no further investigation. ITLs were utilized as a comparative baseline for site-specific analytical results (e.g. to determine whether a release to soil has been delineated or assess whether groundwater impacts are present). These ITLs were used as a preliminary means of focusing any future efforts on the relevant constituents and areas of concern.

For the purposes of this RFI, ITLs represent values which incorporate both risk-based action levels and regulatory levels. As a result, the comparative process for analytical results is simplified.

ITLs were largely derived for soils using Tier 1 levels specified in Cleanup Levels for Missouri (CALM) as of September 2001 and USEPA Region IX Preliminary Remediation Goals (PRGs) as of November 2000. For use as a preliminary conservative screening tool, the more conservative of the CALM residential exposure value (Scenario A), the CALM "leaching to groundwater" value or the USEPA Region IX PRG value was selected as the ITL.

ITLs for groundwater were derived in a similar manner using CALM values. Instances where the CALM values were unavailable, alternative USEPA drinking water standards [maximum

contaminate levels (MCLs), maximum contaminate level goals (MCLGs), or USEPA Region IX PRG values were used.

Soil and groundwater ITLs are presented in Tables 3-2 and 3-3, respectively. These tables also include the relevant CALM-based criteria, PRGs, MCLs, and alternative risk-based reference values (e.g., PRGs), as appropriate.

4.0 Tract 1-North Investigative Results

The results of the soil and groundwater sampling conducted in the North Tract for the RFI are presented in Section 4.0. A copy of the laboratory reports and chain-of-custody forms are included in Appendix EE.

4.1 Study Area A – Upgradient Parcel

Study Area A is shown on Figure 4-1 and is comprised of the Engineering Campus (Buildings 32, 33, and 34), Building 27A, and parking lots for Buildings 29, 32, 33, 34, and 221. The Engineering Campus office buildings were built by McDonnell Douglas in 1955. Based on aerial photographs from 1937 and 1953, the property where these buildings were constructed was an open field/farmland (Golder Associates, 2003). Building 27A was built by McDonnell Douglas in 1999 and never occupied or used for manufacturing. No SWMUs are located in this study area. USTs were historically located at six locations at the Engineering Campus as detailed in Table 2-1. These USTs were used to supply emergency generators and backup fuel to the buildings furnaces and were removed in 1990. Visual inspection during the removal of the USTs by McDonnell Douglas Environmental Department and monitoring conducted during subsequent construction activities in the vicinity of the former USTs indicated no evidence of petroleum constituents, as detailed in the letter from Boeing to the MDNR dated April 21, 2004 (Appendix G). The purpose of the RFI investigation in this area was to obtain upgradient soil and groundwater data.

4.1.1 Investigation Activities

Four soil borings (one completed as a temporary piezometer and three completed as groundwater monitoring wells) were completed in Study Area A as part of the RFI. Four soil samples were selectively analyzed for VOCs, TPHs, PAHs, metals, and cyanide. The groundwater monitoring wells (MW1, MW2, and MW4) were completed in this study area to obtain upgradient groundwater quality data. These three monitoring wells were sampled seven to eight times from 2000 to 2003. The groundwater samples were selectively analyzed for organics (VOCs, TPHs, PAHs, PCBs) and inorganics (metals and cyanide).

4.1.2 Investigation Results

The analytical results for Study Area A are presented in Tables 4-1 (soils), 4-2 (temporary piezometer and monitoring well groundwater, organics) and 4-3 (monitoring well groundwater, inorganics).

Soil

The only constituent in the soil samples that exceeded the ITLs was chrysene [1,500 micrograms per kilogram ($\mu\text{g/kg}$) in soil sample MW1-16]. The only VOCs detected (acetone, methylene chloride, and MEK) are common laboratory contaminants. Given the limited ITL

exceedences (one constituent in one sample) and the relatively low levels of the other detected constituents, the results are not considered indicative of impacts. The constituents detected are likely due to natural or background anthropogenic sources (vehicle emissions, etc.).

Groundwater

The only organic constituent in the groundwater samples that was detected above ITLs was benzene detected in one sample [7.2 micrograms per liter ($\mu\text{g/L}$) in June 2003] from monitoring well MW1. Benzene was not detected in the seven other samples collected from MW1. The benzene detection may be a laboratory contaminant or potentially from an offsite source (see Section 5.0). The only inorganic constituents in groundwater samples that exceeded the ITLs are-were total lead and total chromium. The total lead levels exceed the ITLs in the samples from MW1, MW2, and MW4 for the first sampling event (July 2000) only. Total lead was reported below the ITLs for the other sampling rounds, and the dissolved lead was consistently below the detection limit ($5 \mu\text{g/L}$). The total chromium ITL was exceeded for the samples from MW2 and MW4 for the first sampling event (July 2000). The total chromium ITLs were not exceeded for the other sampling rounds, and the dissolved chromium levels were very low or non-detect.

4.2 Study Area B – North Office Complex

Study Area B has been organized into two divisions: B(1) and B(2) (Figure 4-2).

4.2.1 Study Area Division B(1) – Building 220 (North) and 221

4.2.1.1 Area Description

Study Area Division B(1) is shown in Figure 4-2. A former 5,000-gallon fuel oil UST (B45) was located at the southeast corner of Building 221. This tank was installed in 1954 and removed in 1990. The tank was not replaced. The Building 220 trash compactor had a hydraulic oil system (containing less than 30 gallons of hydraulic oil) which had apparently leaked, resulting in an oil stain on the adjacent asphalt.

4.2.1.2 Investigation Activities

A total of six soil borings and temporary piezometers were completed in Study Area Division B(1) as part of the RFI. No permanent groundwater monitoring wells were installed. The seven soil and six groundwater samples were selectively analyzed for VOCs, TPHs, and metals. Three soil borings/piezometers were completed to assess potential releases from Tank B45, and three soil borings/piezometers were completed to assess potential releases from the Building 220 trash compactor.

4.2.1.3 Investigation Results

The analytical results for Division B(1) are presented in Table 4-4 (soil) and Table 4-5 (temporary piezometer groundwater, organics and inorganics). Groundwater detections above ITLs in Study Area B(1) are presented in Figure 4-3.

Tank B45

The ITL for TPH was exceeded in soil samples B221E1-7 and B221E1-12. Most of the TPH detected was within the DRO fraction range, consistent with the product (fuel oil) stored in UST B45. Two of the three VOCs detected (acetone, methylene chloride) are common laboratory contaminants. The third VOC [~~trichloroethane~~ (TCE) was detected at low levels (below ITLs) and was qualified as J (estimated value) and D (diluted).

The three groundwater samples (B221E1W, B221E2W, and B221E3W) obtained in proximity to UST B45 had no constituents reported above ITLs. TPH GRO was detected in groundwater sample B221E1W, but at a very low level (650 µg/L).

Trash Compactor Hydraulic System

The analytical results for the soil and groundwater samples collected from three soil borings/piezometers (B220N1, B220N2, and B220N3) completed around the trash compactor indicated no VOCs exceeded the ITLs. The TPH ITL, however, was exceeded in the groundwater sample B220N1W, which was collected adjacent to the trash compactor. The total lead ITL was exceeded in groundwater samples from temporary piezometers B220N2 and B220N3. The total lead levels (19.2 and 18.8 µg/L), however, are just above the ITL of 15 µg/L, and there are no known sources of lead in Area B(1). Based on the type of material released (hydraulic oil), the size of the source (small aboveground oil reservoir), and since two nearby borings did not contain TPH detections in soil or groundwater the hydraulic oil release appears to be defined.

4.2.2 Study Area Division B(2) – Building 220 (South)

4.2.2.1 Area Description

This area includes a former TCE vapor degreaser that was located in a chemical processing room within Building 220. The former vapor degreaser was located aboveground and within a concrete containment area. The vapor degreaser was removed in 1998 and not replaced.

4.2.2.2 Investigation Activities

Four soil borings (two completed as temporary piezometers and two completed as monitoring wells) were installed as part of the RFI in Division B(2). These activities were conducted to assess potential releases from the former vapor degreaser. The soil and groundwater samples were selectively analyzed for VOCs, TPHs, and metals. Additionally, in 1998 six soil borings were completed, and confirmatory samples were collected in proximity to the removed degreaser (within the chemical processing) room by Wellington Environmental (1999).

4.2.2.3 Investigation Results

The analytical results for the Division B(2) samples are presented in Tables 4-5 (temporary piezometer groundwater, organics), 4-6 (soils), 4-7 (monitoring well groundwater, organics) and 4-8 (monitoring well groundwater, inorganics). A copy of the vapor degreaser investigation report is included as Appendix FH. The analytical results from the degreaser investigation are discussed below. Groundwater detections above ITLs in Study Area B(2) are presented in Figure 4-3.

Soil

None of the soil samples contained constituents above ITLs. The soil sample B22011-7, however, had detectable levels of TCE (48 µg/kg) and 1,2-DCE (75 µg/kg). This soil boring (B22011) was located closest to the former degreaser. The six soil borings completed in the chemical processing room which contained the vapor degreaser (Wellington Environmental, 1999) contained detectable levels of TCE in three soil samples; SB4 (55 µg/kg), SB5 (54.3 µg/kg) and SB6 (10.6 µg/kg). None of these concentrations exceed the TCE ITL of 100 µg/kg.

Groundwater

The groundwater sample from the temporary piezometer B22011 contained detectable levels of several VOCs (1,1-DCE at 0.88J µg/L; 1,2-DCE at 54D µg/L; and TCE at 220D µg/L, which exceeded the TCE ITL of 5 µg/L). ~~This TCE level exceeded the ITL.~~ This piezometer was located closest to the former vapor degreaser. The two groundwater monitoring wells (MW10S and MW10D), installed downgradient of the degreaser, have been sampled quarterly, starting in September 2000 with a total of 11 sampling events for each monitoring well. The organics 1,1-DCE, cis-1,2-DCE, and vinyl chloride were consistently detected in the shallow groundwater samples from monitoring well MW10S. Only vinyl chloride exceeded the ITL, however, the maximum detection was 3.6 µg/L compared to the ITL of 2 µg/L. Various organics (ethylbenzene, toluene, xylene, and TCE) have been sporadically detected for the deep groundwater samples from monitoring well MW10D. These detections, however, are not consistent and at low levels (near detection limits).

Total lead was detected above the ITL in one of the five samples analyzed for metals from monitoring well MW10D, however, this detection (16 µg/L) was just above the total lead ITL of 15 µg/L. Total lead was detected above the ITL in the initial groundwater sample collected from monitoring well MW10S but was below detection limit or the ITL for the next four sampling events. Chromium was detected above the ITL in the initial two sampling events from well MW10S, and barium was detected above the ITL in the second sampling event from MW10S. Chromium and barium detections were below ITLs for the three sampling events following the exceedences.

4.3 Study Area C – GKN Area

Study Area C has been divided into four study area divisions: C(1) – Buildings 29/29A, C(2) – area between Buildings 29 and 27, C(3) – Building 27 and East Parking Lot, and C(4) – Railroad Area (Figures 4-4 through 4-9).

4.3.1 Study Area Division C(1) – Buildings 29/29A

4.3.1.1 Area Description

Four ~~Three~~ potential areas of concern were identified within Division C(1): SWMU 29, Former Vapor Degreaser in Building 29, Former UST B66, and the Building 221 Maintenance Shop (Figure 4-4).

SWMU 29, Waste Ferracoat, Methyl Ethyl Ketone, and Trichloroethylene Drum Storage, Building 29A

~~Unit~~ SWMU 29 consisted of a small room in the northwest corner of Building 29A. The room is used for satellite accumulation storage of several 55-gallon drums containing waste materials. The drums containing Ferracoat, and spent MEK and TCE generated from manufacturing processes in Building 29A were managed in this unit. The RFA concluded that there was no potential for release from this area and further investigation was not warranted.

Former Vapor Degreaser in Building 29

A TCE degreaser (approximately 240 gallon capacity) was operated inside of Building 29 from 1981 to 1992 when it was replaced with an aqueous degreaser.

Former Tank B66

Tank B66 consisted of a 4,000-gallon hydraulic oil UST that was installed in 1980 and removed in 1994. The tank was not replaced.

Building 21 Maintenance Shop

The maintenance shop loading dock, located adjacent to the railroad tracks, was identified as a potential area of concern due to the use of chemicals in the maintenance shed used to clean and repair equipment.

4.3.1.2 Investigation Activities

Three soil borings/temporary piezometers were completed in Division C(1) as part of the RFI. One soil boring/piezometer was located adjacent to the Former Vapor Degreaser inside Building 29. One soil boring/piezometer was completed near the Former Tank B66. One soil boring/piezometer was completed at near the back door of the Building 221 Maintenance Shop. The soil and groundwater samples were selectively analyzed for VOCs, TPHs, PAHs, and metals.

4.3.1.3 Investigation Results

The analytical results for the Division C(1) samples are presented in Tables 4-9 (soils) and 4-10 (temporary piezometer groundwater, organics and inorganics).

Soils

None of the VOC constituents detected in the three Division C(1) soil samples exceeded ITLs. No other organics (TPHs, PCBs, PAHs) were detected. None of the metal levels detected exceeded ITLs.

Groundwater

None of the groundwater samples contained organic constituents (VOCs, PAHs, TPH) that exceed ITLs. TCE was detected at 2.1 µg/L in the B29I1W sample just above the 1 µg/L method detection limit. TPH (DRO fraction) was reported at 730 µg/L in the B29E1W sample, but is well below the total TPH ITL of 10,000 µg/L.

The one sample (B21S1W) analyzed for inorganic constituents had detections for arsenic, barium, cadmium, chromium, and lead that exceeded ITLs. The metals concentrations are likely higher due to suspended solids in the sample from the temporary piezometer (see Section 6.1).

4.3.2 Division C(2) – Area Between Buildings 29 and 27

Division C(2) is shown on Figure 4-4.

4.3.2.1 Area Description

Seven ~~Ten~~ potential areas of concern were identified in this division and are described below.

SWMU 4, Leaked or Spilled Jet Aircraft Fuel Storage Tank, Building 28

~~Unit~~ SWMU 4 consisted of a 5,000-gallon, double-walled, below-grade tank that stored waste jet fuel. This tank provided less-than-90-day storage of waste jet aircraft fuels collected from leaks or spills that occurred during the testing of aircraft fuel systems. Tank B65 was installed in 1989 and replaced a steel UST (B62) that was installed in 1953. Tank B65 was 8 feet in diameter, and approximately 14 feet long. The top of the tank was approximately 4 feet bgs. The tank was covered and surrounded with river gravel and capped by 3 inches of asphalt and 8 inches of concrete. A leak detection system was installed in the gravel, and the tank had a leak detection system between the double walls. Tank B65 was removed in 2000 and not replaced.

SWMU 5, Reactive Cyanide and Sulfide-Bearing Waste Storage (1989 to 2001)

~~Unit~~ SWMU 5 was a fully enclosed, prefabricated storage building. The steel constructed building had a capacity of twenty-eight 55-gallon drums. The drums rested upon a wire mesh floor on a spill containment system. The spill containment capacity is 380 gallons. The storage building was used from 1989 to 2001. It replaced the former storage area (SWMU 6) for this waste. The building was used for less-than-90-day storage of 55-gallon drums containing

cyanide and sulfide-bearing waste. MDNR Hazardous Waste Program (HWP) Permits section certified this unit as clean closed on November 16, 2001.

SWMU 6, Reactive Cyanide and Sulfide-Bearing Waste Storage (1979-1989)

~~Unit~~ SWMU 6 was located adjacent to ~~Unit~~ SWMU 5. This unit was placed into service in 1977 and replaced in 1989. The building consisted of a 22- by 10-foot structure with a concrete floor. There was a 6-inch high curb surrounding the waste storage area and a 3.5-foot deep sump was located in the northeast corner of the building. The area had a storage capacity of 31 drums. The area surrounding is covered with asphalt and concrete. This unit was used to store 55-gallon drums containing cyanide and sulfide-bearing waste. Storage of waste in this area was discontinued in 1989 because water seepage into the shelter after heavy rains or snowmelt became a regular problem, and the Facility wanted to eliminate the potential hazard of water combining with reactive cyanide wastes.

Closure of this unit was conducted under MDNR HWP Permits section oversight during July-September 1989. MDNR ~~Hazardous Waste Program (HWP)~~ Permits section certified this unit as closed on November 9, 1993.

SWMU 8, Scrap Dock Shelter –

~~Unit~~ SWMU 8 was Boeing's permitted hazardous waste storage facility. The unit was used to store containers (drums/carboys) of various hazardous waste for more than 90 days. A 6-inch high curb divided the scrap dock shelter into two sections. Each section had a 3- by 3- by 2-foot deep sump to accumulate any leakage. Containers of acids, alkalis, and unwashed empty drums that previously had been used for hazardous waste storage were in one section of this shelter. The other section of the shelter stores paint sludges, oils, solvents, and unwashed empty drums that previously held oils or solvents. MDNR HWP Permits section certified this unit as closed on November 16, 2001 with the provision that institutional controls are to be put into place as part of the Final remedy under site-wide corrective action.

SWMU 31, Maintenance Shop Waste Oil Tank, Building 22

SWMU 31 previously consisted of a 740-gallon, single-wall steel, aboveground tank that stored waste oil. This tank provided less-than-90-day storage of waste oil generated from maintenance activities in Building 22. The tank sat on an asphalt pad surrounded by a 6-inch asphalt berm and was adjacent to the west side of Building 22. Since 1996, the Facility has utilized two steel tanks inside of a spill containment building for waste management activities in this area.

SWMU 32, PCB Storage (1987 to 2000)

SWMU 32 was a fully enclosed, prefabricated storage building. The steel constructed building had a capacity of twenty-eight 55-gallon drums. The drums rested upon a wire mesh floor on a spill containment system with a capacity of 380 gallons. The storage building was used from

December 1987 to December 2000. The building was used for less-than-90-day storage of 55-gallon drums containing PCB oil from transformers at McDonnell Douglass.

Scrap Metal Recycle Dock Area

The Recycling Dock area has been used for recycling and accumulating scrap since the Building 27 expansion in 1954. The dock is composed of an elevated ramp and a concrete lined and curbed chip drainage area. Rolloffs containing scrap is a concrete lined and curbed area where aluminum, titanium, and other metal shavings and scrap from the manufacturing process are taken to the top of the elevated ramp and loaded into open-top semi-tractor trailers located on the drainage area below to be hauled off-site to a recycling company. The trailers are inclined to Roll-off bins of metal shavings are tipped into the open tops of tractor trailers and allow the cutting fluid (water based) coolant (cutting oil before 1990) is allowed to drain out of the trailers and into a collection drain. This collection drain is plumbed into an oil/water sump located beneath the elevated area of the dock. The water from the oil/water sump flows into the industrial waste sewer which goes to the Boeing IWTP.

Building 22 Tanks (Tanks B52 to B58)

Seven USTs for gasoline and diesel storage were adjacent to Building 22. Not all of the tanks, however, were present at one time, currently three USTs are in use. These consist of a 10,000-gallon gasoline tank (B56), a 10,000-gallon diesel tank (B58), and an 8,000-gallon gasoline tank (B54). Refer to Table 2-3 for further details on the size of the tanks, material stored and periods of operation.

Building 28 Tanks (Tanks B60, B61, B63 and B64)

Two 5,000-gallon USTs for jet fuel were located next to Building 28 approximately 50 feet west of SWMU4. The original steel USTs (B60 and B61) were installed in 1955 and removed and replaced in 1989 with double walled USTs (B63 and B64). Tanks B63 and B64 were removed in 2000 and not replaced.

Building 39

Building 39 was used to store unused hazardous materials and served as a reception point for hazardous waste before storage in the permitted storage area (SWMU 8). The building was constructed in 1954 and has an attached loading dock and two exterior shelters.

4.3.2.2 Investigation Activities

A total of 37 soil borings (25 completed as temporary piezometers, three as permanent shallow piezometers, six as groundwater monitoring wells, and three as soil borings only) have been installed in Division C(2) as part of the RFI. Additionally, seven monitoring wells (three of which were closed prior to the RFI) and eight soil borings have been installed during previous investigations. A total of 46 soil samples and 121 groundwater samples were selectively analyzed as part of the RFI for VOCs, TPHs, PAHs, PCBs, metals, and cyanide.

4.3.2.3 Investigation Results

The analytical results for the Division C(2) samples are presented in Tables 4-11 (soils), 4-12 (temporary piezometer groundwater, organics and inorganics), 4-13 (monitoring well groundwater, organics) and 4-14 (monitoring well groundwater, inorganics). The groundwater sample analytical results for the three permanent piezometers in the area (RC8D, RC6D, B27W3D) are included in the monitoring well tables. Soil and groundwater detections above ITLs for Study Area C(2) are presented in Figures 4-5 and 4-6, respectively.

Soil

VOCs that exceeded ITLs were reported for four soil samples (B27W3-8, RC1-7, RC3-5 duplicate, and RC6-7). These soil samples were collected from soil borings located in proximity to the scrap recycle dock area. Sample B27W3-8 contained levels of cis-1,2-DCE (1,800 µg/kg), TCE (390 µg/kg), and vinyl chloride (600 µg/kg) that exceed ITLs. Samples RC1-7 and RC6-7 contained vinyl chloride (51 and 28 µg/kg, respectively) above the ITL. The duplicate sample of RC3-5 contained TCE at 120 µg/kg. Sample RC3-5 contained TCE at 98 µg/kg, just below the ITL of 100 µg/kg. Several other soil samples had detectable levels of VOCs, with DCE isomers, TCE and vinyl chloride the most common VOCs detected. Several samples contained detectable levels (but below ITLs) of toluene and xylenes.

Only one soil sample (RC2-7) contained TPH above the ITL with 980,000 µg/kg of TPH DRO. Five other soil samples contained detectable concentrations of TPH-GRO, ranging between 220 µg/kg in RC3-5 and 16,000 µg/kg in the B28N1-7 sample. One soil sample (B27W3-2) was analyzed for pesticides but contained no detectable levels. Twelve soil samples were analyzed for PCBs with one sample (RC2-7) having a detectable level (100 µg/kg).

Sixteen soil samples were analyzed for PAHs with six samples having detectable levels. Two of the soil samples (B22N1-4 and MW-7-7) had one PAH (chrysene) above the ITL (at 300 and 210 µg/kg, respectively). The B22N1-4 sample contained six other PAHs above the detection limit.

Three soil samples contained one metal (arsenic) above the ITL. One of these samples (B27W3-8) was only slightly above the ITL (121,000 µg/kg) with a reported level of 13,500 µg/kg. The B27W3-25 sample was higher at 40,700 µg/kg, and the B27W1-3 sample was higher at 130,000 µg/kg.

Groundwater

The discussion of groundwater results is separated into shallow groundwater and deep groundwater.

Shallow Groundwater

VOCs were detected in groundwater samples obtained from 19 shallow temporary piezometers, three permanent shallow piezometers, and eight shallow monitoring wells in Study Area Division

C(2). Several of these monitoring wells and piezometers have had multiple rounds of sampling and analysis. The most commonly detected VOCs were PCE, TCE, vinyl chloride, and the various DCE isomers. Additional organics (e.g., benzene, toluene) were reported for some groundwater samples. VOCs above ITLs were detected in groundwater samples obtained from 12 shallow temporary piezometers and six monitoring wells. As with soil, the common constituents that exceed ITLs in groundwater were PCE, TCE, vinyl chloride, and the DCE isomers.

The highest levels of VOCs were reported for groundwater samples obtained from monitoring points MW3, MW3A, RC8S, and B27W3S, which are located in the scrap recycle dock area, and monitoring points B28N1 and B28MW1, which are located adjacent to Building 28.

Three permanent piezometers (B27W3D, RC6D, and RC8D) were screened just below the organic silt layer that ~~separates~~ marks the boundary between the shallow and deep groundwater zones. These piezometers are considered to be "intermediate" between the shallow and deep water zones, being screened in the upper few feet of the confining unit of the deep groundwater zone. The confining clay unit in this area is approximately 50 feet thick. The groundwater samples obtained from these piezometers contained detectable levels of VOCs (some above ITLs) but the concentrations were significantly lower than the concentrations observed in the adjacent shallow groundwater samples.

TPH was detected in groundwater samples obtained from monitoring wells B28MW4 and MW3 and in groundwater samples obtained from seven temporary piezometers. Samples from only two temporary piezometers (RC2 and RC3) exceeded the total TPH ITL of 10,000 µg/L with 342,100 µg/L and 49,140 µg/L, respectively. During sampling, an oil sheen and a thin emulsion of dark brown product that had a cutting oil odor was observed on the groundwater in temporary piezometer RC2. The predominant TPH fraction identified in these ~~two samples~~ from RC2 and RC3 was DRO, but also included GRO.

PCBs were detected in the groundwater samples from three temporary piezometers [RC1, RC2, and RC9 (scrap recycle dock area)] at 11 µg/L, 580 µg/L, and 2.8 µg/L, respectively. Each of these concentrations exceeded the PCB ITL of 0.5 µg/L.

PAHs were detected in samples obtained from two piezometers (B22N1 and RC2). The PAH levels in the sample from RC2 [250 µg/L of benzo(a) anthracene and 86 µg/L of chrysene] exceed their respective ITLs of 0.0044 µg/L. The piezometer RC2 is located at the northern end of the scrap recycle dock area.

Total metals were detected in most of the groundwater samples obtained from Study Area Division C(2). In some cases, these metal levels also exceeded the ITLs (Tables 4-12 and 4-14). The total metals that exceeded the ITLs were arsenic, barium, cadmium, chromium,

mercury, and lead. The corresponding dissolved metal levels typically were non-detect or below ITLs.

The highest levels of chromium were reported for samples from temporary piezometers B22E2, B22E3, and B22W1, all of which exceeded 2,000 µg/L. These three samples also had the highest barium detection. The metal concentrations detected in the temporary piezometers are likely higher due to high suspended solids in the samples.

Reactive cyanide was detected in two temporary piezometer groundwater samples (CN1W and HW1W) at a concentration of 110 µg/L_{kg} each.

Deep Groundwater

One deep groundwater monitoring well (MW9D) is located in the Study Area Division C(2). This well has been sampled 11 times, with no detectable levels of VOCs. Several groundwater samples obtained from this well had detectable levels of total metals, with arsenic, barium, chromium, and lead exceeding their respective ITLs for the initial groundwater sample. In the subsequent sampling events, one groundwater sample exceeded the chromium ITL, one groundwater sample exceeded the lead ITL, and one groundwater sample exceeded the mercury ITL. None of the reported metal levels for the MW9D samples consistently exceeded the ITLs.

4.3.3 Study Area Division C(3) – Building 27 and East Parking Lot

4.3.3.1 Area Description

Eight–Nine areas of potential concern were identified within Study Area Division C(3) (Figure 4-7), as described below.

SWMU 18, Methyl Ethyl Ketone/Methyl Isobutyl Ketone Recovery Unit

Unit–SWMU 18 is located within Building 27 and recycled/recovered MEK and MIBK. These solvents were used to clean spray painting guns, lines, and equipment. The system was enclosed in an inner room with concrete floors and stainless steel walls. Spent MEK and MIBK were recycled in this recovery unit, and waste still bottoms were generated. The unit was removed in 1995.

SWMU 30, Chemical Etching Spill Containment Area

Unit–SWMU 30 is the spill containment system for the area within Building 27 where metal parts are chemically etched. The process uses several open-top tanks. The metal parts are dipped into tanks that contain a variety of chemicals. One of the process tanks holds potassium dichromate solution. The solution is filtered to extend its life. Any chemicals that spill out of the chemical etching tanks are managed in this unit. A new tank line and containment system was installed in 2000.

Building 27 Metal Plating Shop

The Metal Plating Shop is comprised of a series of open top tanks suspended above the shallow collection basin that drains to Boeing's IWTP. The tanks, which hold from 100 to 2,000 gallons, contain various acid solutions and rinses. The electroplating process coats metal parts with chromium, cadmium, or nickel.

Building 27 Machinery Pits

Numerous milling machinery pits containing equipment and catch basins for aqueous cutting fluid. These Fourteen of these pits were visually inspected for Boeing in 2000 (HES, 2000) by Heritage Environmental Services, LLC. The inspection concluded that no evidence of cracks or perforations were observed in the inspected sumps with the exception of a crack three feet below the surface along the wall of a sump that was 12 feet deep. No evidence of staining was observed at this elevation in this sump. A copy of this report is included as Appendix I.

Building 27 Aqueous Degreaser

An aqueous degreaser at the northwest corner of Building 27.

Building 27 Vapor Degreaser

A small (approximately 100 gallon capacity) TCE degreaser was operated from the late 1980s to the late 1990s outside of the electroplating shop in the central east side of Building 27.

Industrial Sewer

Two industrial wastewater sewer lines run underneath the parking lot east of Building 27. These sewers provided drainage from the plating and aluminum lines in Building 27 to the IWTP. Following the Fabrications Operations Environmental Investigation in July 2000, the industrial sewers were internally inspected in October 2000 using a video camera and were found to be constructed of cast iron with a notable separation at a specific joint in the vicinity of B27E4 (Figure 4-7). The sewer lines from Building 27 to the first junction manhole (Figure 4-7) were replaced in November 2000 and approximately 75 cubic yards of impacted soil in proximity to the sewer lines were excavated and disposed of as "special waste." This is considered an interim action. Copies of the repair documentation report, soil disposal profile analysis, and manifest are included in Appendix FJ.

Building 25 UST (B59)

Tank B59 consisted of a 8,000-gallon Mmethyl Aalcohol Ttank. The tank was installed in 1984 and removed in 1995.

Building 20 UST (B67)

Tank B67 consisted of a 375-gallon fuel oil tank. The tank was installed in 1943 and removed in 1999.

4.3.3.2 Investigation Activities

A total of 46 soil borings (31 completed as temporary piezometers, eight as shallow monitoring wells, three as deep monitoring wells, and four as soil borings only) were installed in this study area as part of the RFI. Additionally, four monitoring wells (one of which has been closed) were installed during prior investigations. Fifty-three soil samples and 128 groundwater samples were collected for analysis. The soil and groundwater samples were selectively analyzed for VOCs, TPHs, PAHs, metals, and cyanide.

4.3.3.3 Investigation Results

The analytical results for Study Area Division C(3) are presented in Tables 4-15 (soils), 4-16 (temporary piezometer groundwater, organics and inorganics), 4-17 (monitoring well groundwater, organics), 4-18 (monitoring well groundwater, inorganics). Soil and groundwater detections above ITLs in Study Area C(3) are presented in Figures 4-8 and 4-9, respectively.

Soils

VOCs were detected in Division C(3) soil samples (Table 4-15). The VOCs detected consisted of cis-1,2-DCE, ethylbenzene, xylene, and TCE. None of the VOCs detected exceeded the ITLs. The highest levels of VOCs were reported for the B20E1-6 sample with 3,200 µg/kg ethylbenzene and 1,200 µg/kg xylenes. The highest TCE concentration (290 µg/kg) was reported for the B2711-12 samples. Acetone, chloroform, dichlorodifluoromethane, MEK, and methylene chloride were detected at low levels in a number of samples. The constituents are common laboratory contaminants.

Detectable levels of TPH were reported for eight soil samples. The soil samples from four soil borings contained TPHs exceeding the ITL: (B20E2-8, B27E2-12, B27110-9, B2719-9). The predominant petroleum fraction reported for these samples was DRO. No PCBs were detected in the 18 soil samples analyzed for PCBs. The soil borings B2719 and B27110 were located near the machinery pits in Building 27, and soil borings B27E2 and B20E2 were located near Tanks B59 and B67, respectively.

Four of the 18 soil samples (B27E2-12, B2714-5, B2719-9, B27WS3-22) contained detectable levels of PAHs but none exceeded the ITLs. The highest PAH level (chrysene at 740 µg/kg) was reported for the B2719-9 soil sample (Building 27 machinery pit).

Soil samples from four borings (B27E1-9, B2716-8, MW-6-13, and MW8AS-12 DUP) contained metals that exceeded the ITLs. Arsenic was exceeded in three of the soil samples with the highest level at 17,700 µg/kg in the MW-6-13 sample. The chromium ITL was exceeded in three samples with the highest level at 114,000 µg/kg reported for the B2716-8 DUP sample.

Shallow Groundwater

Detectable levels of VOCs were reported from groundwater samples obtained from 15 temporary piezometers and five shallow groundwater monitoring wells. The most commonly detected VOCs were PCE, TCE, vinyl chloride, and the DCE isomers. ~~These same~~ One or more of these VOCs exceeded the ITLs in groundwater samples from seven piezometers and four monitoring wells.

The groundwater ITL exceedences are located in three areas: (1) the metal plating shop, SWMU 18 and 30 industrial sewer; (2) near a machinery pit; and (3) near the industrial sewer on the east parking lot (see Figure 4-9).

The highest PCE exceedence (24.5 µg/L) was reported for the groundwater sample from temporary piezometer B27E12 (plating shop industrial sewer). The highest TCE ITL exceedence was reported for the sample from temporary piezometer B27E1 at 2,700 µg/L (plating shop industrial sewer). The groundwater samples obtained from monitoring wells MW5AS and MW5 have consistently exceeded the TCE ITL. Most of the groundwater samples obtained from monitoring wells MW5AS and MW5 exceeded the vinyl chloride ITL. Three of the piezometer groundwater samples exceeded the vinyl chloride ITL with a maximum detection of 31 µg/L reported for the sample from B27I1.

The maximum cis-1,2-DCE ITL exceedence (196.3 µg/L) was reported for the B27E4 piezometer sample. Most of the groundwater samples obtained from monitoring well MW5AS also exceeded the cis-1,2-DCE ITL of 70 µg/L.

The other VOCs detected (usually at low levels) included benzene, toluene, and common laboratory contaminants such as acetone, MEK, and methylene chloride. TCE was detected in ~~deep~~ monitoring well ~~MW5AD-MW8~~ twice ~~once~~ out of 11 sampling events (~~18-7.3 µg/L and 1.6 µg/L~~). In the last ~~four~~ five sample events, TCE has been below method detection limits of 1.0 µg/L. A similar pattern of detection of TCE from one out of 11 sample events (7.3 µg/L) was ~~noted in monitoring well MW8~~. Note that this detection came in the same quarterly sampling event (first quarter 2002) as the 18 µg/L detection in the deep monitoring well MW5AD and, therefore, they are likely both the result of laboratory or field contamination.

TPH was detected in groundwater samples obtained from ten temporary piezometers, and four shallow groundwater monitoring wells. The most commonly reported TPH fraction was DRO. The maximum level was 120,000 µg/L TPH DRO (120,110 µg/L total TPH) from the piezometer B27I9 located adjacent to ~~the~~ a machinery pit. The TPH ITL was also exceeded in the B27E2 groundwater sample (Tank B59 area). None of the groundwater samples from the monitoring wells exceeded the ITLs. The monitoring well B25MW1 and B25MW4 samples, however, have consistently reported detectable levels of TPH (but below ITLs).

None of the groundwater samples obtained from Division C(3) contained detectable levels of PAHs, PCBs, or cyanide.

Total metals were detected in each of the piezometer and monitoring well samples that were analyzed for metals. Total metal ITLs were exceeded in groundwater samples obtained from 19 temporary piezometers and ten monitoring wells. Most of the monitoring well sample exceedences were in the first round and only one of the dissolved metal concentrations (B27E4, plating shop area) exceeded ITLs.

Total chromium, however, was significantly higher in the groundwater samples obtained in the vicinity of the plating shop industrial sewer from piezometers B27E1 and B27E4 with 49,000 µg/L and 15,500 µg/L, respectively. The sample obtained from B27E4 was analyzed for dissolved chromium with 13,500 µg/L reported, which is above the total chromium ITL. Figure 4-10 presents the results of total chromium analysis in groundwater for Study Area Division C(3)

Detectable levels of dissolved chromium were reported for groundwater samples obtained from monitoring wells MW5AS, and MW5, and MW6D. None of these levels, however exceeded the chromium ITL. Hexavalent chromium analysis was selectively performed for groundwater samples obtained from monitoring wells MW5AS and MW5. The MW5 samples contained no detectable levels of hexavalent chromium. Detectable levels of hexavalent chromium were reported for five out of the nine samples obtained from monitoring well MW5AS. The highest level detected was 20 µg/L of hexavalent chromium.

Deep Groundwater

Three deep groundwater monitoring wells (MW5AD, MW6D, and MW8AD) are located in the Study Area Division C(3). These wells were sampled 11 times, the only detections of VOCs were benzene detected one time each in MW6D and MW8AD at 1.6 µg/L and 1.7 µg/L, respectively and TCE which was detected in MW5AD twice out of 11 sampling events (18 µg/L and 1.6 µg/L). In the last four sample events, TCE has been below method detection limits of 1.0 µg/L and the TCE detections were likely the result of laboratory or field contamination.

Groundwater samples obtained from these deep wells had detectable levels of total metals. Arsenic, barium, chromium, and lead exceeded their respective ITLs for the initial groundwater sample in MW6D. Chromium and lead exceeded their respective ITLs for the initial groundwater sample in MW5AD and MW8AD. In the subsequent sampling events, the only total metal ITL that was exceeded was lead in MW8AD at 22 µg/L.

4.3.4 Division C(4) – Railroad Area

4.3.4.1 Area Description

This study area division consists of Facility property adjacent to the offsite railroad tracks along the north side of Banshee Road.

4.3.4.2 Investigation Activities

Four soil borings and one soil boring/temporary piezometer were completed in this division. The soil samples were analyzed for pesticides. The one groundwater sample was analyzed for metals.

4.3.4.3 Investigation Results

The Division C(4) analytical results are presented in Tables 4-19 (soils) and 4-20 (temporary piezometer groundwater, inorganics).

Soils

None of the soil samples contained detectable levels of pesticides.

Groundwater

The groundwater sample from temporary piezometer RR5 contained detectable levels of total metals with total lead exceeding the ITL. The dissolved lead level (11.3 µg/L), however, was below the total lead ITL of 15 µg/L.

5.0 Tract 1-South Investigative Results

The results of the soil and groundwater sampling conducted in the South Tract for the RFI are presented in Section 5.0. A copy of the laboratory reports and chain-of-custody forms are included in Appendix EE.

5.1 Study Area D – SWMU 17

Study Area D consists of Buildings 51, 52, 48, 48A, and part of 45K. Buildings 51 and 52 were demolished down to the floor slabs in 2002. Study Area D has been separated into three divisions: D(1), D(2), and D(3) (Figure 5-1). Given the proximity of the potential areas of concern, the study area description includes all of Study Area D. The study area investigation activities and investigation results are divided according to Division D(1), D(2), and D(3).

5.1.1 Area Description

SWMU 1, Waste Sodium Hydroxide ASTs

Waste sodium hydroxide solution was managed at this unit from 1966 to 2000. The waste was generated from chemical milling of aluminum at Building 52. Two different sets of 10,000-gallon ASTs were used to store the waste. The first set of two 10,000-gallon steel ASTs were in operation from 1966 to May 1988, when they were removed. The second set of two 10,000-gallon ASTs were in operation from May 1988 to 2000. The second set of ASTs and associated piping were constructed of carbon steel. The tanks were 16 feet tall. These tanks rested upon a 6-inch thick concrete pad, surrounded by a 6-inch thick asphalt spill pad. The spill pad was underlain by 6 to 12 inches of crushed limestone base rock over clayey backfill. The asphalt pad was surrounded by a 9-inch high asphalt curb. The area inside the asphalt curb drained to the IWTP. After the first set of tanks had been removed, soil sampling was conducted at this unit in 1993 as part of RCRA closure activities. The results of the soil sampling are presented in the RFA. MDNR HWP Permits section certified this unit closed on August 5~~Closure of this unit was obtained in, 2003.~~

SWMU 2, Waste Nitric and Hydrofluoric Acid Solution Storage, Tanks H12, H13, H14, Building 52

Unit SWMU 2 consisted of three 850-gallon ASTs. These tanks were used for less-than-90-day storage of waste nitric acid (57 percent) and hydrofluoric acid (8 percent) solution from chemical milling of titanium. They were installed in 1986 and removed in 2001. Each tank was approximately 12 feet tall. The tanks were constructed of polyolefin and were heated to maintain an internal temperature of 130°F. The tanks were supported on a wooden platform constructed of 6-inch by 6-inch wooden beams. The platform was raised about 4 feet above the ground and supported on concrete piers. The area beneath the tanks is surrounded on three sides by a 6-inch high asphalt curb. The curb abuts the foundation wall of Building 52. The spill containment area within the asphalt curb is underlain by 6 to 12 inches of crushed limestone

base rock over a bentonite lining. The spill containment area slopes from the perimeter to a PVC drain located in the center of the curbed area. The drain is connected to the IWTP.

Before October 1986, five 500-gallon polyethylene tanks were used to store the nitric and hydrofluoric waste. A closure investigation of the former tanks was conducted concurrently at this unit and SWMU 1 in 1993. The results are presented in the RFA. MDNR HWP Permits section certified this unit closed on August 5, 2003.

SWMU 9, Waste Nitric and Hydrofluoric Acid Solution Storage, Building 52

Unit SWMU 9 consisted of six 750-gallon aboveground storage tanks located adjacent to the south wall of Building 52. All six tanks were open top, cylindrical, one piece molded high density, black polyethylene plastic. Each tank was approximately 6 feet in height and 55 inches in diameter. The tanks were structurally supported on a wooden platform. The area under the tanks and platform was sealed with a 3-inch thick asphalt pad. This pad was surrounded by a 6-inch high asphalt curb. Inside the curb was a 4-inch thick layer of crushed limestone and a drain to the IWTP. Waste nitric acid (40 percent concentration) and hydrofluoric acid (4 percent concentration) solution from chemical milling of titanium were managed in this unit.

SWMU 15, Waste Jet Fuel Storage Tank, Ramp Station 1 and 2

Unit SWMU 12 was a 4,380-gallon fiberglass UST, located at Building 45K. The tank was used from 1983 to June 1993 to store jet aircraft fuel that had leaked or been spilled during the repair of aircraft fuel systems. The tank was removed in August 1993 and not replaced.

SWMU 16, MEK/MIBK Recovery Unit, Building 48

Unit SWMU 16 was a MEK and MIBK recycling/recovery unit located within Building 48. These solvents were used to clean spray painting guns, lines, and equipment. The system was enclosed in an inner room with concrete floors and stainless steel walls. Spent MEK and MIBK were recycled in this recovery unit. Waste still bottoms were collected in drums for subsequent disposal.

SWMU 17, Transfer Area for Recovered PCE – SWMU 17 is a continuously paved area outside of Building 51 that was used for tank transfer activities involving recovered perchloroethylene (PCE). Boeing initially began using this unit for PCE recovery operations in 1993. The unit contained a series of tanks which were utilized to store the separated PCE stream while being transferred from a 55-gallon tank to a 750-gallon holding tank, and finally into various 350-gallon portable tanks for offsite shipment. The distillation unit was removed from operation in February 1998; Boeing no longer uses this area for PCE recovery purposes. During the VSI, evidence of past spills in the area where the 350-gallon portable tanks were filled werewas observed. Asphalt around the transfer area was noted to be damaged.

The referenced waste management activities were used to recover PCE from maskant that is applied to sections of various metal parts. The maskant product is a mixture of rubber-like

polymers in a PCE carrier or thinner. This paint-like mixture is applied to metal parts and allowed to dry. As the parts dried, the PCE evaporated and was captured in a vapor recovery hood. Vapors from the hood were discharged to a carbon adsorption unit, where the PCE vapors were separated from the air and then transferred to a condenser, where it was recovered. The recovered PCE flowed to a 55-gallon receiving tank that cycled it to the 750-gallon holding tank. Recovered PCE was then transferred from the 750-gallon holding tank into 350-gallon portable tanks for offsite shipment.

Activated granular carbon represented the only residue generated from the PCE recovery process. Spent carbon was shipped offsite for incineration at approximate 5-year intervals.

SWMU 25, Less-Than-90-Day Storage Area, Building 51

SWMU 25 was a prefabricated storage building located outside the east side of Building 51. The steel-constructed building had the capacity to store twenty-eight 55-gallon drums. The storage unit was open on all sides and had a corrugated steel roof. A sunken floor provided a spill containment capacity of 380 gallons.

Waste solvents, paints, and oils generated in Building 51 were placed in 55-gallon drums throughout the building. When full, the drums were transferred to this storage area, as well as drums from satellite accumulation areas. The SWMU 25 storage building was ~~had been~~ used at this location between ~~since~~ June 1989 and ~~and~~ December 2000.

The RFA concluded that there was no significant potential release to soil or groundwater from this unit.

SWMU 27, Waste Nitric and Hydrofluoric Acid Scrubber Saddles Drums Storage, Building 52

~~Unit~~ SWMU 27 consisted of ten 55-gallon drums located outside the southeast corner of Building 52. The drums contained waste plastic packing saddles used in the nitric and hydrochloric acid fume scrubber within the building. The plastic packing saddles were rinsed prior to being drummed.

Boeing personnel indicated that the drums were placed at this location in fall 1990 and were removed in November 1993. The packing saddles were sent to a sanitary landfill with other facility trash for disposal. The drums were crushed and also sent to the landfill.

The area where the drums were placed was paved with asphalt and concrete. There was no spill containment system for this storage area. Based on the observations from the VSI, four soil samples were collected at this unit during the sampling visit. The samples were collected from depths of 0 to 12 and 12 to 24 inches bgs at locations outside a wooden fence and between the parking posts.

Analytical results for these RFA samples indicated that no organic constituents were detected, with one exception. PCE was detected below its ITL in two samples. Inorganic constituents were detected, primarily metals. Only arsenic and mercury were detected above ITLs.

Building 51 UST (Tank B32)

This UST consisted of a 6,000-gallon solvent tank which was installed in 1977. This UST was removed in April 1986 and not replaced.

Former 15,000 Gallon ASTs

A 1958 vintage facility drawing indicates the presence of a 15,000-gallon fuel oil tank located north of Building 48. A 1958 aerial photograph confirms the presence of a single AST located in this area. A 1979 facility drawing shows two ASTs within containment located in this same area and shows the presence of a fuel distribution system. These ASTs are clearly indicated on a 1985 aerial photograph (Golder, 2003). The fuel distribution lines from this storage unit ran east-west along the southern side of former Building 51 and also into former Building 53.

Airport USTs

At total of 14 USTs owned by Airport Terminal Services, Inc. were located on Airport property at 5310 Banshee Road, immediately west (upgradient) of the Facility. These USTs, which have been removed, ranged in size from 1,000-gallons to 20,000-gallons and were registered as containing gasoline. A release to soil and groundwater was reported to the MDNR in April 1992 (LUST Incident number ID R003285-U001158503). Remedial action including tank closure, excavation, and monitoring was reported to be completed in 1998.

During 2002, the Airport collected site characterization data from geotechnical borings for the Airport Expansion Program in the area of the former USTs. Soil and groundwater samples were collected by the Airport for laboratory analysis if impact was observed. These samples were used as a screening to define if remediation is needed in areas scheduled for future construction of Airport buildings, access roads, and utility line construction. Soil and groundwater samples were analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX), methyl tertiary-butyl ether (MTBE), TPH DRO and TPH GRO.

Four soil borings (B7, B8, B27, and B-2002) were installed by the Airport on Boeing property (Figure 5-1). Soil collected from three of the four borings contained detectable concentrations of benzene, ranging from 102 $\mu\text{g/kg}$ to 225 $\mu\text{g/kg}$, above the benzene ITL of 50 $\mu\text{g/kg}$. Toluene, ethylbenzene and xylenes detections were below ITLs. MTBE was below method detection limit in all four soil samples. TPH (about evenly divided between GRO and DRO fractions) was detected in all four soil samples with a maximum total TPH detection of 61,020 $\mu\text{g/kg}$, below the total TPH ITL of 200,000 $\mu\text{g/kg}$. A groundwater sample was collected from one of these borings (B7) and found to contain benzene at a concentration of 817 $\mu\text{g/L}$ and total TPH at 112,000 $\mu\text{g/L}$, both values above ITLs of 5 $\mu\text{g/L}$ and 10,000 $\mu\text{g/L}$, respectively. Toluene (33 $\mu\text{g/L}$), ethylbenzene (130 $\mu\text{g/L}$) and xylenes (140 $\mu\text{g/L}$) were detected at levels below ITLs.

MTBE was below detection limit in this sample. A summary of the soil and groundwater results from these borings is presented in Table 5-1.

A total of 13 additional groundwater samples were collected by the Airport from soil borings located on the property adjacent to the Facility. Benzene concentrations ranged from less than method detection limits to 21,100 µg/L with seven of the eight detections being greater than the ITL of 5 µg/L. Toluene concentrations ranged from less than method detection limits to 840 µg/L with two of the five detections (310 µg/L and 840 µg/L) being greater than the ITL of 150 µg/L. Ethylbenzene concentrations ranged from less than method detection limits to 2,600 µg/L with one of the six detections above the ITL of 700 µg/L. Total xylenes concentrations ranged from less than method detection limits to 660 µg/L with one of the four detections above the ITL of 320 µg/L. MTBE was detected in one sample (37 µg/L), above the ITL of 20 µg/L. Total TPH was detected in 12 of the 13 groundwater samples ranging from 200 µg/L to 1,269,200 µg/L, with seven of the 12 detections above the ITL of 10,000 µg/L.

Groundwater data from 2002 sampling of 10 shallow monitoring wells located on Airport property west of the Facility indicated that benzene was detected in three of the 10 wells at concentrations of 7.01 µg/L, 13.4 µg/L and 18.2 µg/L, all above ITL. Other detections were below their respective ITLs. Toluene was detected in two of the wells (3.2 µg/L and 4.3 µg/L), ethylbenzene was detected in one well (2.0 µg/L), MTBE was detected in one well (3.1 µg/L) and total TPH was detected in three of the wells ranging from 2,150 µg/L to 3,400 µg/L. Total xylenes were not detected in the groundwater samples from the 10 monitoring wells.

Subsequent soil remediation and removal of water from impacted areas was reported to have been conducted during grading of the area for construction activities in 2002/2003 (Golick, 2003).

5.1.2 Investigation Activities

Division D(1) (West Section)

A total of 11 soil borings (eight temporary piezometers, two groundwater monitoring wells, and one soil boring only) were completed in Division D(1) as part of the RFI. A total of ten soil samples and eight groundwater samples from temporary piezometers were collected for analysis. The two groundwater monitoring wells were sampled 10 times each. The D(1) samples were selectively analyzed for VOCs, TPHs, and metals. Five monitoring wells were installed as part of a previous investigation, and one of these monitoring wells (MW-A8) was sampled twice for total and dissolved metals.

Division D(2) (Center Section)

A total of 24 soil brings (14 temporary piezometers, four permanent piezometers, three groundwater monitoring wells, and three soil borings only) have been completed in Division D(2) as part of the RFI. A total of 389 soil samples were collected for analysis. Each of the 14 temporary piezometers were sampled once. Each of the permanent piezometers and

monitoring wells were sampled between three and ~~eleven~~^{nine} times. The Division D(2) samples were selectively analyzed for VOCs, TPHs, and metals.

Division D(3) (Eastern Section)

A total of 19 soil borings (nine temporary piezometers, three permanent piezometers, five monitoring wells, and two soil borings only) were completed in Division D(3) as part of the RFI. A total of 14 soil samples were collected and analyzed. Each of the nine temporary piezometers were sampled once. Each of the permanent piezometers and monitoring wells were sampled between four and 11 times.

5.1.3 Investigation Results

Division D(1) (Western Section)

The analytical results for the Division D(1) samples are presented in Tables 5-2 (soils), 5-3 (temporary piezometer groundwater, organics and inorganics), 5-4 (monitoring well groundwater, organics), and 5-4~~5~~ (monitoring well groundwater, inorganics). The soil and groundwater detections above ITLs are presented in Figures 5-2 and 5-3, respectively.

Soils

~~Eight~~^{Seven} of the ten soil samples had detectable levels of VOCs. None of the VOCs detected exceeded the ITLs. The most commonly detected VOC was PCE with a maximum level of 58 µg/kg in the SB-8 11.5-12.5 soil sample. TCE was detected in one sample (B51W3-12) at 50 µg/kg. MEK was detected in three samples with a maximum level of 6,100 µg/kg in the SB-25-6 sample. DCE isomers were detected in ~~two~~^{three} samples. Xylene was detected in one sample (B51W2-6) at 90 µg/kg.

TPH was detected in three soil samples but none of the levels exceeded the ITL. In two of the samples (SB-25-6 and SB-34-8), the TPH consisted of DRO, and in one sample (B51W2-6), the TPH consisted of GRO. Lead was detected in the two samples it was analyzed for but the levels were below ITL.

Shallow Groundwater

VOCs were detected in all eight temporary piezometer groundwater samples. The most commonly detected VOCs were PCE, TCE, and the DCE isomers. Benzene, toluene, and xylene were also detected. The ITL for benzene was exceeded in the sample from B51W2, which also contained toluene and xylene. This sample was located at the westernmost facility property boundary and is immediately downgradient of the airport UST area. The ITLs for cis-1,2-DCE, PCE, and TCE were exceeded in the TP-10 groundwater sample which also contained 2,000 µg/L of TPH (DRO).

TPH was detected in five of the eight temporary piezometer groundwater samples. The TPH ITL was exceeded in the sample from B51W2 (1,300,000 µg/L) (airport UST area) and the TP-23 sample (212,199 µg/L). The TPH fraction in the sample from B51W2 was predominantly GRO,

but included DRO. The TPH fraction in the sample from TP-23 was DRO. Two of the Division D(1) temporary piezometer groundwater samples were analyzed for lead, but no detectable levels were reported.

~~The two one Division D(1) RFI monitoring RFI shallow wells (MW-8S) were sampled 10 times each for VOCs. The MW-8S samples consistently contained detectable levels of PCE which twice exceeded the ITL. The maximum detection, however, was 5.8 µg/L versus the PCE ITL of 5.0 µg/L. The MW-8S samples also contained detectable levels of cis-1,2-DCE, TCE, and methyl tert-butyl ether (MTBE) but none of the levels exceeded ITLs. TPH DRO fraction was detected at levels just above method detection limits in three of the ten sampling events. PCE and TCE were each detected in intermediate monitoring well MW-8I one time out of the ten sampling events (13 µg/L and 8.9 µg/L, respectively). Each detection was above ITL but could be the result of laboratory or field contamination. TPH DRO was detected twice out of ten sampling events at levels just above method detection limit and well below the TPH ITL.~~

~~The MW-8S samples consistently contained detectable levels of PCE which twice exceeded the ITL. The maximum detection, however, was 5.8 µg/L versus the PCE ITL of 5.0 µg/L. The MW-8S samples also contained detectable levels of cis-1,2-DCE, TCE, and methyl tert-butyl ether (MTBE) but none of the levels exceeded ITLs. TPH DRO fraction was detected at levels just above method detection limits in three of the ten sampling events.~~

One monitoring well, (MW-A8), (not installed as part of the RFI), was sampled twice for total and dissolved metals. The total arsenic, total cadmium, and total lead ITLs were exceeded in these samples. None of the dissolved metal levels exceeded total metal ITLs.

Deep Groundwater

The one Division D(1) monitoring RFI deep well (MW-8I) was sampled 10 times for VOCs. MW-8I is located adjacent to the shallow well MW-8S and is screened between 32 and 42 feet bgs in clay of the intermediate deep zone. PCE and TCE were each detected in MW-8I one time out of the ten sampling events (13 µg/L and 8.9 µg/L, respectively). Each detection was above ITL but could be the result of laboratory or field contamination. No other VOC was detected from the 10 samples analyzed. TPH DRO was detected twice out of ten sampling events at levels just above method detection limit and considerably below the total TPH ITL.

Division D(2) (Center Section)

The analytical results for the Division D(2) samples are presented in Tables 5-6 (soils), 5-7 (temporary piezometers groundwater, organics and inorganics), 5-8 (monitoring well groundwater, organics), and 5-9 (monitoring well groundwater, inorganics). This study area division contained SWMUs 1, 17, and 25.

Soils

Most (30 of 38) of the Division D(2) soil samples contained detectable levels of VOCs, and 21 soil samples had detections above ITLs. The VOCs that exceeded ITLs were PCE, TCE, vinyl chloride, cis-1,2-DCE, 1,1,2-TCE, and various DCE isomers. The highest PCE levels were reported for soil samples from soil borings SB-1, SB-2, SB-3, SB-4, SB18, and TP-5. The highest PCE (9,300,000 µg/kg) and TCE (14,000 µg/kg) levels were reported for the SB-18-15 sample. Elevated TCE levels were reported for soil samples from soil borings SB-9, and TP-5. Various other VOCs (i.e., ethylbenzene, toluene, xylene, etc.) were also detected at levels below ITLs.

The highest DCE isomer levels were reported for the soil samples obtained from SB-4, SB-18, and TP-5. Each of these borings had soil samples which exceeded the DCE ITL. The highest DCE level (68,000 µg/kg) was reported for the SB-18-15 sample.

Seven of the Division D(2) soil samples contained detectable levels of TPH-DRO with five of the detections above the TPH ITL. The highest level (2,080,000 µg/kg) was reported for the SB-5 5.5-7 soil sample.

Eleven of the Division D(2) soil samples were analyzed for metals. Arsenic was the only metal constituent detected above ITL, with two of these exceedences from Boring SB-1 (20,000 µg/kg at 12-13 feet and 15,000 µg/kg at 16-17 feet). The other ITL exceedence was in SB-4_6-7 at 20,000 µg/kg.

Shallow Groundwater

VOCs were detected in ten of the 14 temporary piezometer groundwater samples with seven containing VOCs above ITLs. The predominant VOCs detected were PCE, TCE, vinyl chloride, and DCE isomers.

The highest PCE level (86,000 µg/L) and the highest TCE level (920 µg/L) were reported for the groundwater sample from SB18. The highest DCE isomer level (cis-1,2-DCE at 9,300 µg/L) and the highest vinyl chloride level (1,600 µg/L) were reported for the groundwater sample from TP-11.

TPH was detected in ten out of 13 temporary piezometer groundwater samples. The TPH ITL was exceeded in five of these samples. The highest level (1,100,000 µg/L) was reported for the sample from TP-9. The TPH fraction reported for each of the piezometer samples was DRO. One temporary piezometer groundwater sample was analyzed for total metals with two detected above ITLs, cadmium (5.4 µg/L versus 5.0 µg/L ITL) and arsenic (130 µg/L versus 50 µg/L ITL).

Each of the seven shallow monitoring wells/permanent piezometers in Division D(2) have been sampled several times, ranging from three times for piezometer TP-1 to 44 nine times for piezometers TP-2 and TP-4 ~~for MW-5I~~. Groundwater samples from each of these monitoring

points had detectable levels of VOCs. The most commonly detected VOCs were PCE, TCE, vinyl chloride, and DCE isomers. Other VOCs detected included 1,1,2-TCE, benzene, and toluene. Groundwater samples from each of these monitoring points also exceeded VOC ITLs. The highest levels of PCE, TCE, and cis-1,2-DCE were reported for groundwater samples obtained from MW-7S, TP-2, TP-4, and TP-5. These monitoring points are closest to the stained area identified in the VSI. The highest level of PCE (490,000 µg/L) was reported for a sample obtained from MW-7S. The highest level of TCE (270,000 µg/L) was reported for a sample obtained from MW-5I/TP-5. The highest levels of cis-1,2-DCE (97,000 µg/L) was reported for a sample obtained from TP-1, the highest level and vinyl chloride (4,400 µg/L) was reported for a sample obtained from TP-1 and TP-5, respectively.

Detectable levels of TPH were reported for groundwater samples obtained from each monitoring point. The TPH detections, however, were not always consistent with some sample rounds having non-TPH was below method -detection limits-levels.

The TPH ITL was exceeded in samples obtained from five-four of the monitoring points. The highest total TPH level (110,000 µg/L) was reported for the sample from TP-1 (SWMU 17). The GRO TPH fraction detections were typically much higher than DRO fraction detections.

Groundwater samples from two of the shallow monitoring points (TP-1 and TP-4) were sampled for select total and dissolved metals. None of the total or dissolved metal levels exceeded the ITLs.

Deep Groundwater

The one Division D(2) monitoring RFI deep well (MW-5I) was sampled 11 times for VOCs. MW-5I is located adjacent to the shallow well MW-6S and is screened between 32 and 42 feet bgs in clay of the intermediate deep zone. Seven VOCs (excluding methylene chloride which was detected in the method blank) were detected above ITLs in at least one of the 11 sample events. The VOC constituents detected at the highest concentrations were TCE, cis-DCE, and vinyl chloride, all breakdown components of PCE. This contrasts with much higher PCE concentrations relative to breakdown constituents in the shallow zone, which indicates that reductive dechlorination is occurring faster in the intermediate deep zone, most likely as a result of more reductive (anaerobic) conditions at depth (see Section 6.3). The highest concentration of TCE detected at the Facility (270,000 µg/L) was reported for a sample obtained from MW-5I. TPH GRO was detected at a concentration of 100,000 µg/L, above the total TPH ITL. TPH DRO was detected three times out of ten sample analyses at levels just above method detection limit and considerably below the total TPH ITL.

Division D(3) (Eastern Section)

The analytical results for the Division D(3) samples are presented in Tables 5-10 (soils), 5-11 (temporary piezometer groundwater, organics and inorganics), and 5-12 (monitoring well groundwater, organics).

Soils

VOCs were detected in 11 of the 14 soil samples collected in Division D(3). The VOCs detected consisted of isopropyl benzene (three samples), MEK (two samples), naphthalene (one sample), n-butylbenzene (five samples), n-propylbenzene (three samples, p-isopropyltoluene (one sample), sec-butylbenzene (five samples, and toluene (one sample). The highest MEK level was 3,900 µg/kg in the SB-21-8 sample. The highest sec-butylbenzene level was 540 µg/kg in the SB-31-6 sample. The only constituent exceeding ITLs was p-isopropyltoluene at 130 µg/kg in the SB-31-6 sample.

TPH was detected in ten of the Division D(3) soil samples. The TPH fraction identified for each sample was DRO with one sample also containing GRO (SB-6 9.5-11). The TPH ITL was exceeded in six of the soil samples with a maximum level of 1,400,000 µg/kg in the SB-30-6 sample (location of piezometer TP-15). One sample (B48E1-8) was analyzed for lead with a reported level of 8,2105,000 µg/kg which is below the ITL.

Shallow Groundwater

VOCs were detected in groundwater samples obtained in ~~eight-six~~ of the ~~eight-six~~ shallow monitoring wells/permanent piezometers in Division D(3). Each of the monitoring points were sampled several times (up to 11 times for TP-3MW11D). The most commonly detected constituents were PCE and TCE. A variety of other VOCs were also detected in the groundwater samples. These were predominantly petroleum based constituents including benzene, isopropyl benzene, n-propylbenzene, p-isopropyltoluene, and naphthalene.

The ITLs were exceeded for PCE; TCE; vinyl chloride; DCE isomers; n-butylbenzene; sec-butylbenzene; benzene; 1,2,4-trimethylbenzene; MTBE; naphthalene; toluene; and xylenes, although the exceedences were (generally) not uniformly consistent between sampling rounds. The highest PCE level (7,100 µg/L) was reported for one of the samples collected from TP-3 samples. The highest TCE level detected was 5,300 µg/L in one of the samples collected from TP-3-samples. The highest and only detected level of vinyl chloride (55 µg/L) was reported for a MW-9S sample. The highest benzene level (680 µg/L) was reported for one of the samples collected from TP-3-samples.

TPH was detected at least once in samples obtained from each of the monitoring points. ~~Several of the monitoring points, however, had TPH~~ was detected only once out of ~~several 10~~ sampling rounds (~~i.e., MW-11, MW-11D, in MW-11S~~). Groundwater samples obtained from monitoring points MW-10S, MW-9S, TP-3, and TP-6 consistently had detectable levels of TPH. The TPH ITL was exceeded (in samples obtained from at least one sampling round) from

monitoring points MW-10S, TP-3, and TP-6. The most commonly reported fraction was DRO. The highest TPH level—concentration (330,000 µg/kg) was reported for the onea sample collected from MW-10S sample. A petroleum sheen was observed on groundwater in TP-6, MW-9S, and MW-10S during most sampling events. During some sample events, a very dark brown product emulsion which had an oil/diesel odor was observed on top of the groundwater in MW10S.

VOCs were detected in two of the nine temporary piezometers with benzene detected in temporary piezometer SB-20 (piezometer was overdrilled for the installation of MW-9S), the only VOC constituent detected above ITL (7 µg/L versus 5 µg/L ITL). TPH was detected in all seven groundwater samples from temporary piezometers, all TPH detections were DRO fraction. Three of the TPH detections were above the TPH ITL of 10,000 µg/L—ITL; TP-7 at 1,000,000 µg/L; TP-15 at 2,200,000 µg/L; and TP-16 at 2,100,000 µg/L. One temporary piezometer groundwater sample (B48E1W) was analyzed for total lead which was not detected.

Deep Groundwater

The two Division D(3) monitoring RFI deep wells, MW-11I and MW-11D, were sampled for VOCs 10 and 11 times, respectively. MW-11I and MW-11D are located adjacent to the shallow well MW-11S. MW-11I is screened between 30 and 40 feet bgs in clay of the intermediate deep zone. MW-11D was drilled to refusal on shale bedrock at 75.3 feet bgs and is screened between 64 and 74 feet bgs. The only VOC detections in MW-11I were singular detections during different sample events (10 total) of bromomethane, 1,2,dichloropropane, and TCE. Bromomethane and 1,2,dichloropropane were detected at 1.2 µg/L and 2 µg/L, respectively. There is not an ITL established for bromomethane, the ITL for 1,2,dichloropropane is 5 µg/L. TCE was detected one time (December 2002) in MW-11I at a concentration of 12 µg/L. TCE was below method detection limit of 1 µg/L in the other nine sampling events, including the two sampling events in 2003. TPH DRO was detected one time out of 10 sample events at a concentration just above method detection limit (140 µg/L versus 100 µg/L detection limit) and considerably below the total TPH ITL.

The only VOC detected in monitoring well MW-11D was TCE which was detected in five of the 10 sample events. Two of the TCE detections (17 µg/L and 5.2 µg/L) were above the ITL of 5 µg/L. The TCE results for the last four sampling events (August 2002 through June 2003) were below ITL with the last three events below the method detection limit of 1 µg/L for TCE. TPH DRO was detected one time out of 10 sample events at a concentration just above method detection limit (120 µg/L versus 100 µg/L detection limit) and considerably below the total TPH ITL. Note that this detection was in a duplicate sample and that TPH was below method detection limit in the split sample.

5.2 Study Area E

The Study Area E has been divided into six divisions: E(1), E(2), E(3), E(4), E(5), and E(6).

5.2.1 Division E(1) – Jet Fuel Hydrant Area

The Study Area Division E(1) is presented in Figure 5-4.

5.2.1.1 Area Description

SWMU 14, Waste Jet Aircraft Fuel Storage Tanks at Fuel Pits 3 and 4 – Unit SWMU 14 consisted of two 2,000-gallon, vertical USTs (Tanks B29 and B30) within fuel pits located approximately 40 feet south of Building 45. Each tank had a nominal capacity of about 3,000 gallons, but the bottom third of each was filled with concrete. Fuel Pit 3 tank was installed in 1977. Fuel pit 4 tank was installed in 1983. Both tanks were removed in August 1992.

The fuel pits are concrete-lined subgrade excavations that house the pumps and filters used for fueling and defueling aircraft. While the tanks were in place, whenever the pumps in the fuel pits were turned on, a valve opened so that any spilled fuel would automatically go into the tank. A concrete slab covered the tanks and the entire area where the tanks were located. These tanks were used to store jet aircraft fuel that spilled during fueling or defueling operations.

As part of investigation and remedial action conducted at the SWMU 14 area (also referred to as Site No. 4), 11 monitoring wells (MW-A5, MW-A14, MW-A15, MW-A22, MW-A23, MW-A24, MW-A25, MW-A26, MW-A27, MW-A28, MW-A29) were installed (ATEC, 1990, Riedel, 1990). Free phase product was observed in six of these 11 wells immediately after their installation in 1989. Product recovery and groundwater remedial action consisting of vacuum removal of water from select wells in the area with a vac-truck was conducted on a monthly basis from 1990 through 1998. Free product has not been observed in these 11 wells since 1992.

Jet Fuel Hydrant Lines

Based on information determined from historical Facility drawings, the distribution of past or present jet fuel lines are presented on Figure 5-4. The primary distribution lines run from the Building 41 Tank Farm to the aircraft fueling area at Fuel Pits 1, 2, 3, and 4. These are underground lines which have historically run between Buildings 45 and 42, to the southeast corner of Building 48. From here they have progressed either diagonally through the parking lot near Building 44 or along the south and east edges of this parking lot. ~~Fuel Pits 1 and 2 were previously connected to a tank farm near Building 43.~~ The current jet fuel lines were installed in 1989 following a piping failure near the southeast corner of Building 48.

As part of investigation and remedial action conducted in the vicinity of the piping failure (also referred to as Site No. 1), six monitoring wells (MW-A9, MW-A10, MW-A11, MW-A12, MW-A13, and MW-A20) were installed (ATEC, 1990, Riedel, 1990). Free phase product was observed in four of these six wells immediately after their installation in 1989. Product recovery and

groundwater remedial action consisting of vacuum removal of water from select wells in the area with a vac-truck was conducted on a monthly basis from 1990 through 1998.

Building 43 Tank Farm

Fuel Pits 1 and 2 were previously connected to a tank farm near Building 43. This tank farm, which reportedly was also connected with via underground piping to the tank farm at Building 41, consisted of five 20,000-gallon steel USTs (B33 to 37) that contained jet fuel (Figure 5-4). These tanks were installed in 1957 and removed in 1991. During removal, the presence of impacted soil was confirmed upon the excavation of the USTs discovered and 799 cubic yards of soil were removed for offsite disposal. Confirmatory—Five confirmatory soil samples were collected from the UST excavation and analyzed for BTEX and total TPH. The results of laboratory analysis indicated that toluene was the only constituent detected, with a maximum detection of 10 µg/kg. Based on the results of the confirmatory sampling indicated that impacted soils had been removed and the MDNR granted clean—a No Further Action determination closure for the closure of the USTs—in a letter dated June 6, 1995.

Aviation Refueling Station

An aviation gasoline refueling station was formerly located west of Building 2, with a short distribution system running north-south connecting to a former UST (B68).

Building 45 UST (Tank B25)

A 335-gallon diesel UST which was installed in 1958 and used to supply fuel to an emergency generator which was removed from service in 1976. At that time, the diesel was removed from the UST and it was filled with sand. The UST was subsequently removed in 1987. The tank was not replaced.

5.2.1.2 Investigation Activities

A total of 39 soil borings, all completed as temporary piezometers were installed in Study Area Division E(1) as part of the RFI. In addition, 19 groundwater monitoring wells were installed in this area during previous investigations. Four of these monitoring wells have been closed. A total of 36 soil samples, 38 groundwater samples from temporary piezometers and eight groundwater samples from five monitoring wells were selectively analyzed for VOCs, TPH and metals.

5.2.1.3 Investigation Results

The analytical results for the Division E(1) samples are presented in Tables 5-13 (soils), 5-14 (temporary piezometer groundwater, organics and inorganics), and 5-15 (monitoring well groundwater, organics). Total TPH in soil and total benzene in soil isopleth maps are presented in Figures 5-5 and 5-6, respectively. Total TPH in groundwater and benzene in groundwater isopleth maps are presented in Figures 5-7 and 5-8, respectively. The soil and groundwater impacts in this study area are attributed to the fuel hydrant lines, and the associated petroleum USTs.

Soils

Twenty-one of the 36 soil samples contained detectable levels of VOCs. The most commonly detected VOCs were petroleum constituents; benzene, toluene, xylenes, and benzene derivatives (i.e. n-propylbenzene), etc. The benzene ITL was exceeded in 910 soil samples, with a maximum level of 1,170 µg/kg reported for the B42E1-5 sample. Other than methylene chloride, a common laboratory contaminant, none of the other VOCs detected exceeded their respective ITLs. The maximum toluene level (3,200 µg/kg) was reported for the B45S2-7 soil sample. The maximum xylene level (829 µg/L) was reported for sample B48S1-6.

TPH was detected in 24 of the 35 soil samples analyzed for TPH, with the total TPH ITL exceeded in seven samples. The predominate TPH fraction reported was GRO, but many of the samples also contain the DRO fraction. The maximum level of total TPH detected (1,377,000 µg/kg) was reported for the B48S11-3 soil sample. Eleven of the Division E(1) soil samples were analyzed for lead. None of the reported lead levels exceeded ITLs.

Groundwater

Twenty of the 38 groundwater samples obtained from temporary piezometers contained detectable levels of VOCs. The most frequently reported VOCs were petroleum constituents (e.g. benzene, benzene derivatives, xylene, toluene, etc.). Several samples contained chlorinated compounds (vinyl chloride, DCE isomers, etc.).

The benzene ITL was exceeded in nineteen of the groundwater samples obtained from temporary piezometers, with a maximum reported level (1,720,924 µg/L) for the sample from B428S25W. The toluene ITL was exceeded in one sample (B42W1W) at 395 µg/L. The B42S5W sample contained several VOCs above ITLs; n-butylbenzene (1,200 µg/L), n-propylbenzene (1,300 µg/L), sec-butylbenzene (1,000 µg/L) and xylenes (3,100 µg/L). The groundwater sample from B42N5 contained threetwo constituents (cis-1, 2-DCE at 760 µg/L, MTBE at 24 µg/L, and vinyl chloride at 12 µg/L) that exceeded their respective ITLs.

Twenty-seven of the groundwater samples obtained from temporary piezometers contained detectable levels of TPH. Both DRO and GRO TPH fractions were reported. The total TPH ITL was exceeded in 13 of the piezometer groundwater samples, with a maximum level of 3,284,000 µg/L (predominately DRO) in the sample from B42S5. Nine of the piezometer groundwater samples were analyzed for total and/or dissolved lead. Total lead was detected in one sample from B42E3 at 46 µg/L, which exceeds the ITL.

Five groundwater monitoring wells were sampled for VOCs and TPH. Three of the wells were sampled twice. Both rounds of analysis for monitoring well MW-A23 exceeded the ITL for benzene, with a maximum of 29 µg/L. The sample from MW-A13 exceeded the ITL for MTBE with a reported level of 59 µg/L. Several other petroleum-derived constituents (ethylbenzene, xylenes, etc.) were detected in the monitoring well groundwater samples, but none exceeded

their ITLs. TPH was detected in groundwater samples obtained from four of the monitoring wells. None of the total TPH levels exceeded the ITL. The maximum total TPH detection (7,300 µg/L) was reported from MW-A23. The TPH fractions for this sample were almost equally divided between GRO and DRO. No inorganic analysis was performed for Division E(1) groundwater monitoring well samples.

5.2.2 Division E(2) – UST Area 3

The Study Area Division E(2) is presented in Figure 5-9.

5.2.2.1 Area Description

SWMU 13 UST Site #3 (Ramp Area Adjacent to Buildings 45L, 45C, 45D, and 45E (Hush Houses))

The Hush Houses adjacent to UST Site #3 are used for aircraft testing/maintenance purposes. One 3,380-gallon UST (B26) was utilized between Buildings 45C and 45D for storage of waste fuel (JP-4 and/or JP-5) between 1963 and 1983. The UST was excavated and replaced in 1983 with a UST of the same size (B27). Tank B27 was excavated in June 1989 after releases were documented and the tank was not replaced.

Soil and groundwater sampling activities were conducted to assess potential impacts to soil and/or groundwater (ATEC, 1990). A total of 21 shallow soil samples were collected from five soil borings for offsite laboratory analysis. The samples were collected from depth intervals ranging from 0 to 8 feet bgs.

Variable TPH and BTEX concentrations were detected in three of the five soil borings (A1, A2, and A3 which were subsequently completed as MW-A1, MW-A2, and MW-A3). The highest TPH concentration of 4,800,000 µg/kg was detected in soil sample A2-1. Soil sample A2-1 also exhibited the highest BTEX level of 438,000 µg/kg. Soil samples collected from soil boring A1 exhibited detectable TPH concentrations ranging from 1,200 to 290,000 µg/kg. Soil samples A1-3 and A1-8 exhibited detectable BTEX concentrations of 43 µg/kg and 37 µg/kg, respectively. With the exception of BTEX levels for soil sample A1-8, TPH/BTEX levels generally decreased with depth.

Seven groundwater monitoring wells (MW-A1, MW-A2, MW-A3, MW-A4, MW-A17, MW-A18, and MW-A21) were installed between Buildings 45C and 45D to assess potential groundwater impacts (Figure 5-9). Monitoring well MW-A21 was completed in the backfill of the former UST, MW-A1 was located hydraulically downgradient of the former UST, MW-A2 was placed adjacent to a utility trench that reportedly caused a localized gradient toward MW-A2, and MW-A18 was installed approximately 5 feet north of a 42-inch storm sewer (depth of approximately 9 feet bgs) that runs in a west to east direction. Three of the seven groundwater samples (MW-A1, MW-A2, and MW-A21) exhibited detectable TPH and BTEX levels. Groundwater sample MW-A21 exhibited the highest TPH level of 82,000 µg/L. Groundwater samples MW-A2,

MW-A21, and MW-A1 exhibited detectable BTEX concentrations of 4,870 µg/L; 1,000 µg/L; and 610 µg/L, respectively.

Following the initial investigation of UST Site #3, Boeing subsequently began conducting periodic groundwater remediation/monitoring efforts in 1990 in cooperation with the MDNR UST Division. Two additional monitoring wells (B45CMW-3A and B45CMW-3B) were installed in 1995. Free phase product or a petroleum sheen was observed in seven of the eight wells at the time of installation. Product recovery and groundwater remedial action consisting of vacuum removal of water from select wells in the area with a vac-truck was conducted on a monthly basis from 1990 through February 2002. Based on quarterly sampling results, TPH/BTEX concentrations in groundwater decreased from November 1990 through December 2000.

SWMU 12, Waste Jet Aircraft and Hydraulic System Spillage, F-18 Silencer

Unit SWMU 12 was a 2,130-gallon horizontal UST (Tank B28) located east of the Hush House (Building 45C). This tank received waste fuel and hydraulic systems spillage from the F-18 Silencer building. If a fuel system failed on an engine undergoing testing, any leaked fuel flowed through a drain to an oil-water separator and then into the tank. A concrete slab covered the tank, as well as the general area where the tank was located. The tank was used from 1978 until December 30, 1992, when it was removed. MDNR approved the area as closed.

SWMU 23, Less-Than-90-Day Storage Area

Unit SWMU 23 was a prefabricated steel storage building located south of Buildings 45C and 45D in the Ramp Area. It had inside dimensions of about 14 feet by 8 feet with a capacity of twenty-eight 55-gallon drums. The area around this building is paved. A sunken floor to this storage building provides a spill containment capacity of 380 gallons. Wastes generated in Building 40 and at other satellite areas are placed in 55-gallon drums. When full, the drums were transferred to this storage area. Waste solvents, paints, and oils were stored in this unit.

5.2.2.2 Investigation Activities

A total of three soil borings (one shallow temporary piezometers and two deep temporary piezometers) have been installed in Division E(2) as part of the RFI. A total of two soil samples, three groundwater samples from temporary piezometers, and six groundwater samples from five groundwater monitoring wells were selectively analyzed for VOCs, TPH, and metals.

5.2.2.3 Investigation Results

The analytical results for the Division E(2) samples are presented in Tables 5-16 (soils), 5-17 (temporary piezometer groundwater, organics), 5-18 (monitoring well groundwater, organics), and 5-19 (monitoring well groundwater, inorganics).

Soils

The two soil samples were analyzed for TPH DRO and GRO, and contained no detectable levels.

Groundwater

The three groundwater samples obtained from temporary piezometers (two deep and one shallow) contained no detectable levels of VOCs, TPH DRO or TPH GRO.

SevenFive Division E(2) monitoring wells were sampled once for VOCs and TPH, except MW-A18, which was sampled twice. Groundwater samples obtained from the five~~seven~~ monitoring wells contained detectable levels of VOCs. The sample from MW-A15 contained benzene (34 µg/L), which exceeds the ITL, and isopropyl benzene (14 µg/L). The second round of sampling for MW-A18 resulted in one VOC (MEK) being reported at 4.2 µg/L (likely laboratory contaminant). The sample from MW-A1 contained detectable levels of ethylbenzene (1 µg /L), MTBE (11 µg/L) and xylene (2.1 µg/L), all below ITL. The sample from MW-A3 contained detectable levels of several VOCs (MTBE, isopropyl benzene, etc.) at low levels, none of which exceeded ITLs. Groundwater samples obtained from each of the five monitoring wells contained detectable levels of TPH, with the predominate fraction consisting of DRO, with lower levels of the GRO fraction reported for most samples. The total TPH ITL was exceeded in the samples from wells MW-A1 and MW-A3. The maximum level (20,900 µg/L) of total TPH was detected in the MW-A1 sample.

Note that free phase product was discovered in MW-A1 and B45CMW-3A in June 2003 (prior to the above referenced sampling). Well MW-A1 contained approximately 0.08 feet of product, and well B45CMW-3A contained approximately 0.02 feet of product. Boeing has been bailing each of these two wells twice per month to remove product. As of September 2003, each well has a petroleum sheen but no measurable product level.

Two groundwater samples from MW-A1 were analyzed for total and dissolved metals with numerous metals detected with one detected above ITL (arsenic at 51 µg/L vs. a 50 µg/L ITL).

5.2.3 Division E(3) – Building 40

Study Area Division E(3) is presented in Figure 5-10.

5.2.3.1 Area Description

Unit SWMU 26, Former Less-Than-90-Day Storage Area, Building 40

Unit SWMU 26 was a prefabricated storage building located outside on the northwest side of Building 40. The steel-constructed building had inside dimensions of about 14 feet by 8 feet and had a capacity of twenty-eight 55-gallon drums. The storage unit was open in front and enclosed on the other three sides. A sunken floor provided a spill containment capacity of 380 gallons.

Waste solvents, paints, and oils generated in Building 40 were placed in 55-gallon drums throughout the building. When full, the drums were transferred to this storage area, as well as

drums from other satellite accumulation areas. The storage building was used at this location from November 1990 until July 1993.

During the VSI, stains on and cracking of the concrete paving around the area were observed. Based on these observations, four soil samples were collected at this unit during the sampling visit. Samples were collected from depths of 0 to 12 and 12 to 24 inches bgs at two locations: one along a crack next to the building and one along a seam in the concrete (total of four samples).

Analytical results for these samples indicated that no organic constituents were detected. Inorganic constituents were detected, however, only arsenic was detected above its ITL and may not have been elevated above background.

Interim corrective action measures were completed at this unit in 1997 (HES, 1997). These measures consisted of cleaning and sealing cracks in the existing surface concrete surrounding the storage building. Additional measures were not considered necessary for SWMU 26.

Building 40

Building 40 was used as a maintenance shop.

5.2.3.2 Investigation Activities

A total of eight soil borings (five which were completed as temporary piezometers) were installed in Division E(3) as part of this RFI. A total of 12 soil samples and five groundwater samples were selectively analyzed for VOCs, TPH DRO, and metals.

5.2.3.3 Investigation Results

The analytical results for the Division E(3) samples are presented in Tables 5-20 (soils) and 5-21 (temporary piezometer groundwater, organics).

Soils

None of the Division E(3) soil samples contained detectable levels of VOCs or TPH other than acetone, a common laboratory contaminant. None of the soil samples contained metal levels exceeding the ITLs.

Groundwater – One of the five groundwater samples contained detectable levels of VOCs. The groundwater sample from temporary piezometer B40E1 contained TCE at 1.1 µg/L, which is just above the method detection limit, and below the TCE ITL of 5 µg/L. None of the groundwater samples contained detectable levels of TPH DRO.

5.2.4 Division E(4) – Industrial Sewer Line

Study Area Division E(4) is presented in Figure 5-11.

5.2.4.1 Area Description

This area contains an industrial sewer line that traverses the north side of the South Tract in a general west to east direction. The sewer has been utilized to convey wastewater from various process operations in Building 51 to the IWTP located to the east of the Facility.

Sewer line repairs have been conducted along various piping sections (Figure 5-11). Excavated soil generated by these repair activities has been sampled, submitted for limited laboratory analysis, and managed/disposed in accordance with applicable regulations. None of the soil samples were reported to have exhibited hazardous waste characteristics.

5.2.4.2 Investigation Activities

A total of eight soil borings/ temporary piezometers were completed in Division E(4) as part of the RFI. No groundwater monitoring wells were installed. A total of eight soil samples and eight groundwater samples from temporary piezometers were selectively analyzed for VOCs, TPH and metals.

5.2.4.3 Investigation Results

The analytical results for the Division E(4) samples are presented in Tables 5-22 (soils) and 5-23 (temporary piezometer groundwater, organics and inorganics).

Soils

Five of the eight soil samples contained detectable levels of VOCs, but none exceeded their respective ITLs. TPCE was reported at 1.9 and 1.4 µg/kg in the B2N3-8 and B2N4-6 soil samples respectively. The B44N1-9 sample contained detectable levels of benzene, xylene, n-propylbenzene, p-isopropyltoluene and sec-butylbenzene; none of the levels exceeded ITLs. One of the three soil samples analyzed for TPH contained detectable levels of TPH. The B2N7-6 sample contained 11,260 µg/kg of DRO fraction TPH, which is well below the total TPH ITL of 200,000 µg/kg.

Six of the soil samples were analyzed for metals. The arsenic ITL was exceeded in one sample (B2N2-8) with a reported level of 39,000 µg/kg. The beryllium ITL was exceeded in two samples, with a maximum level of 385 µg/kg reported for the B2N7-6 samples. The selenium ITL was exceeded in one sample (B2N7-6) with a reported level of 5,200 µg/kg.

Groundwater

Three of the groundwater samples contained detectable levels of VOCs. The most commonly reported VOCs were PCE, TCE and DCE isomers. The PCE ITL was exceeded in samples from temporary piezometers B2N3 and B2N4 (23 and 13 µg/L, respectively). The TCE ITL was also exceeded in these two samples with a maximum level of 11 µg/L in the sample from B2N3. Note that piezometers B2N3 and B2N4 were located downgradient of where the industrial sewer makes a 90 degree bend to the north and where a repair of the industrial sewer was made by Boeing several years ago. Piezometers B2N7 (located upgradient of the repair) and B27E15

[located along the industrial sewer on the North Track (see Section 4.3.3)] did not contain VOCs other than common laboratory contaminants which were detected in the B2N7 sample.

Two groundwater samples (B2N6W and B2N7W) contained detectable levels of DRO fraction TPH, but the maximum level (208 µg/L) was well below the ITL.

Several of the groundwater samples contained one or more metal concentrations exceeding ITLs. Total arsenic, barium, cadmium and chromium was exceeded in one sample each, with no discernable pattern. The total lead ITL was exceeded in four groundwater samples with a maximum level of 110 µg/L reported for two samples (B2N3W and B44N1W).

5.2.5 Division E(5) – Building 41 and SWMU 22

Study Area Division E(5) is presented in Figure 5-11.

5.2.5.1 Area Description

Building 41

Building 41 historically been used for the drummed storage of various product oils, solvents, and other chemicals. In addition, aerial photographs taken throughout the 1950s indicate the presence of drum storage areas to the north and south of Building 41. Several photographs displayed the accumulation of more than 100 drums at these outdoor drum storage areas.

Building 41 Tank Farm

Thirteen fuel USTs (B1 to B13) were previously located to the immediate west of Building 41 in an area that has historically been used as a tank farm. The USTs were utilized in the area during various time period beginning in 1947. Two USTs were removed in 1957, four USTs were removed in 1981 (including one used for product solvent), and the remaining seven USTs were removed in 1989. The tank farm area was subsequently renovated and presently contains six USTs (B14 to B19). The current USTs include four 30,000-gallon jet fuel tanks, one 8,000-gallon gasoline tank, and one 8,000-gallon former jet fuel tank that currently is out of service and contains water. Boeing installed and presently maintains a leak detection system in association with the tank farm area.

Soil and groundwater sampling activities were conducted to assess potential impacts to soil and/or groundwater (Burns & McDonnell, 1989). A total of seven shallow soil samples were collected for offsite laboratory analysis from eight soil borings which were converted into groundwater monitoring wells, B41MW-3, B41MW-5, B41MW-7, B41MW-17, B41MW-18, B41MW-19, and B41MW-20 (Figure 5-12). The samples were collected from depth intervals ranging from 0 to 11 feet bgs.

TPH concentrations were detected in three of the seven soil borings. Soil samples collected from these soil borings exhibited detectable total TPH concentrations ranging from 85,000 to 149,000 µg/kg. The highest total TPH concentration of 149,000 µg/kg was detected in the soil sample from B41MW-17. The soil sample from B41MW-5 was also analyzed for VOCs, but none were detected. Soil samples collected at or below the groundwater interface exhibited the highest total TPH concentrations.

TPH concentrations were detected in groundwater samples from four of the eight monitoring wells. TPH levels ranged from 2,200 to 4,300 µg/L, below the total TPH ITL. Chlorinated VOCs were also detected in the groundwater sample collected from B41MW-5. VOC concentrations of 18 µg/L PCE, 9.5 µg/L TCE, 24 µg/L 1,1-DCE, and 5.4 µg/L 1,1-DCE were detected at B41MW-5.

SWMU 22, Paint Booth Satellite Accumulation Drum, Building 2

Painting operations are conducted inside the western portion of Building 2. Hazardous wastes (waste paint and solvents) from these painting operations are accumulated in a 55-gallon drum along an outside western wall of Building 2 (SWMU 22). One drum of paint waste is generated at this unit every 10 to 14 days. This location has been used as a satellite accumulation point since 1990.

As part of the RFA in 1995 (SAIC, 1995), pavement areas around the waste drum were stained with paint. Cracks were also observed in the concrete surrounding the drum. As a result, one soil sample was collected for offsite laboratory analysis of VOCs and metals to assess potential impacts to subsurface soil. The sample was collected from a depth interval of 0 to 2 feet bgs. Xylene was the only VOC detected in the sample at a concentration of 12 µg/kg. Concentrations of various inorganic constituents were comparable to levels detected at other areas of the Facility. The RFA sampling location for the area west of Building 2 is displayed in Figure 5-12.

During the RFA, a 4-foot by 5-foot area of wooden timbers was also observed along the exterior wall of Building 2. The timbers were flush with the surrounding pavement and tightly fit so that the area beneath the timbers could not be observed. The area beneath the timbers was subsequently determined to be a former storm water drain trap.

Two interim measures were completed at SWMU 22 in 1997 (HES, 1997). Surface cracks at the unit were sealed with a new 1-inch layer of asphalt covering an approximately 25-foot by 25-foot area. In addition, the former storm water trap was vacuumed, backfilled with gravel, and sealed with a 6-inch concrete pad. Wastewater and sludges from the removal activities were transported to the IWTP for disposal.

Additional measures were not considered necessary for SWMU 22.

5.2.5.2 Investigation Activities

A total of 12 soil borings (eight completed as shallow temporary piezometers, two as deep temporary piezometers, and two as permanent deep piezometers) were completed in Division E(5) as part of this RFI. As previously noted, eight monitoring wells were installed in the area during previous investigations. Five of these monitoring wells have been closed (Figure 5-12). A total of nine soil samples, ten groundwater samples (eight shallow and two deep) from temporary piezometers and four groundwater samples from shallow monitoring wells (B41MW-5 was sampled twice) and two groundwater samples from deep permanent piezometers were selectively analyzed for VOCs, TPHs, PAHs and metals.

5.2.5.3 Investigation Results

The analytical results for the Division E(5) samples are presented in Tables 5-24 (soils), 5-25 (temporary piezometer groundwater organics and inorganics), and 5-26 (monitoring well permanent piezometer groundwater, organics).

Soils

VOCs were detected in four of the nine soil samples, but none of the levels exceeded ITLs. Primarily petroleum derived constituents (i.e. benzene, toluene, xylene and various derivatives) were detected. The highest VOC levels were reported for the B2I1-8 sample, which contained 292 µg/kg of isopropyl benzene and 268 µg/kg of p-isopropyl toluene.

TPH (DRO fraction) was detected in two samples (B41S3D-4) at 24,000 µg/kg and B2WI-6 at 47,000 µg/kg, which are below the total TPH ITL. One PAH [benzo(A)pyrene] was detected in the seven samples analyzed for PAHs, sample B41E1-10 at 85 µg/kg, which exceeded the ITL. Two of the Division E(5) soil samples were analyzed for metals, with none of the levels exceeding ITLs.

Shallow Groundwater

Five of the eight groundwater samples obtained from shallow temporary piezometers contained detectable levels of VOCs. The sample from B41N1 contained seven different VOCs with levels exceeding the ITLs for 1,2,4-trimethylbenzene, benzene, and n-propylbenzene. The sample from temporary piezometer B2I1 contained one detectable VOC, vinyl chloride at 5.6 µg/L above the ITL of 2.0 µg/L. The sample from temporary piezometer B2W1 contained three detectable VOCs, two of which, benzene at 6.3 µg/L and chloroethane at 7.3 µg/L exceeded the ITLs of 5 µg/L and 4.6 µg/L, respectively.

None of the groundwater samples obtained from shallow temporary piezometers contained detectable levels of TPH. Two of the groundwater samples (B2I1W and B2W1W) were analyzed for metals, with none of the reported levels exceeding ITLs.

Two of the four groundwater samples (both from B41MW-5) collected from shallow groundwater wells contained detectable levels of VOCs. In one sample event, 1,1-DCE and 1,4-dioxane were detected above ITL. Vinyl chloride was detected above ITL in both sample events with a maximum detection of 8.4 µg/L. PCE and TCE were detected at low levels (below ITLs). Note that the PCE, TCE, and 1,1-DCE concentrations have declined since the 1989 groundwater sampling event while vinyl chloride concentrations increased above the method detection limit, indicating that breakdown of the chlorinated compounds is occurring.

Deep Groundwater

The two groundwater samples collected from deep temporary piezometers (B41S3D and B41E1D) were analyzed for VOCs and TPH DRO. The only detection was cis-1,2-DCE at

16 µg/L and PCE at 125 µg/L in the sample from B41S3D; the PCE detection exceeded the ITL of 5 µg/L. Temporary piezometer B41S3D is located approximately 110 feet west of monitoring well B41MW-5, which also had detectable concentrations of PCE and DCE.

The groundwater samples collected from the two permanent deep piezometers (B41S5D and B41E2D) were analyzed for VOCs with no detections. The results from B41E1D, B41S5D and B41E2D indicate that VOCs are not present downgradient of the B41S3D sample location. Note that temporary piezometer B41S3D was located south of Building 41 adjacent to a surface water drain inlet and near the Building 41 (chemical storage) loading dock. Drum storage was also identified to have occurred along the east side of Building 41 and the surface drainage from this area would be to the south and west.

5.2.6 Division E(6) – Building 1 UST and Building 2 UST

Study Area Division E(6) is presented in Figure 5-12.

5.2.6.1 Area Description

Building 1 UST

The Building 1 tanks consisted of four USTs used to store gasoline and diesel fuel. Refer to Table 2-1 for the details of tank sizes, material stored, and periods of operation.

Building 2 UST

The Building 2 tank consisted of a 1,000-gallon diesel UST B24 located at the east side of Building 2. This tank was installed in 1942 and removed in 1989. The tank was not replaced.

Unit-SWMU 24, Less-Than-90-Day Storage Area, Building 2

Unit-SWMU 24 was a prefabricated storage building located outside the east side of Building 2. The steel-constructed building had inside dimensions of about 14 feet by 8 feet and had a capacity of twenty-eight 55-gallon drums. The storage unit was open in front and enclosed on the other three sides. The area around this building is paved. A sunken floor provides a spill containment capacity of 380 gallons. Waste solvents, paints, and oils generated in Building 2 were placed in 55-gallon drums throughout the building. When full, the drums were transferred to this storage area as well as drums from the satellite accumulation areas.

5.2.6.2 Investigation Activities

A total of six soil borings/temporary piezometers were completed in Division E(6) as part of the RFI. A total of six soil and six groundwater samples were selectively analyzed for VOCs, TPH, PAHs and total lead.

5.2.6.3 Investigation Results

The analytical results for the Division E(6) samples are presented in Tables 5-27 (soils) and 5-28 (temporary piezometer groundwater, organics and inorganics).

Soils

Three of the soil samples contained detectable levels of VOCs, with petroleum derived constituents exceeding several ITLs. The benzene ITL was exceeded in three soil samples (B2E1-7, B2E2-8, and B2S2-7) with 1,3240 µg/kg, 184 µg/kg, and 939 µg/kg respectively. The B2S2-7 sample also exceeded the MTBE, p-isopropyltoluene, and toluene ITLs with 180 µg/kg, 520 µg/kg, and 7,600 µg/kg respectively.

TPH was detected in three of the soil samples, with two samples exceeding the ITL. Samples B2E1-7 and B2S2-7 contained 496,000 µg/kg and 1,473,280 µg/kg respectively. Both GRO and DRO TPH fractions were reported. None of the soil total lead levels exceeded ITLs.

Groundwater

Four of the groundwater samples contained detectable levels of VOCs. Again, petroleum derived constituents were detected. The ITLs were exceeded for several VOCs, including benzene, ethylbenzene, toluene, xylene, MTBE, naphthalene, and n-propylbenzene. The sample from temporary piezometer B2E2 contained the highest levels of VOCs, and the largest number (seven) of individual constituent ITL exceedences. The sample from B2S2 had benzene above the ITL of 5 µg/L, with 660 µg/L. The sample from B2S2 also exceeded the MTBE, toluene and xylene ITLs.

Three of the groundwater samples contained detectable levels of TPH, with the samples from B2E2 and B2S2 exceeding the ITL. The maximum TPH level (99,800 µg/L) was reported for the sample from B2E2. Both DRO and GRO TPH fractions were reported.

Total lead was detected in one of the three Division E(6) groundwater samples analyzed. The sample from B2E2 contained lead at 71 µg/L which is above the total lead ITL of 15 µg/L.

5.3 Study Area F – Power Plant Area

Study Area Division F is presented in Figure 5-13.

5.3.1 Area Description

SWMU 10, Waste Oil Tank at Building 5

SWMU 10 is a 375-gallon steel aboveground storage tank located adjacent to Building 5. The tank has been used since December 23, 1988 as a storage unit for waste oil that has been separated from condensate of an oil-lubricated, steam-operated air compressor inside Building 5. The tank was removed in 1997 and replaced with a 375-gallon AST located inside Building 5.

The tank was filled automatically from an oil-water separator that received the discharge stream from the air compressor. Once the tank became full, waste oil was subsequently transferred from the tank to a mobile 1,000-gallon tank at approximate 3- to 5-month intervals. The mobile tank was then moved to the permitted hazardous waste storage area (Scrap Dock Shelter,

SWMU 8) where the waste oil was transferred to a tanker truck for transport to an offsite fuel blending facility.

Interim corrective action measures were completed at this unit in 1997 (HES, 1997). These measures consisted of:

- Cleaning and removing the former AST and secondary containment berm.
- Cleaning the concrete pad beneath the AST with a high pressure citra-clean and water wash.
- Replacing the AST with a secondarily contained 375-gallon AST inside Building 5.

Additional measures were not considered necessary for SWMU 10.

SWMU 11, Former Waste Oil Tank, Building 6

Unit 11 consists of a 1,000-gallon horizontal, below grade carbon steel tank located at Building 6. The tank was strapped to a subsurface concrete pad on which it rested. The tank and the associated hydrocarbon sensing system, in operation since 1970, were removed on December 23, 1988. MDNR certified this unit closed after a visual inspection of the area during the VSI. This unit was used to store oil that had been separated from condensate of an oil-lubricated, steam-operated air compressor.

SWMU 28, Leaking Transformer, Building 6

Unit-SWMU 28 was an electrical transformer system located outside the northeast corner of Building 6. The transformer was on a concrete slab surrounded by gravel but no containment system. The unit contains transformer oil (D098). Analytical results for the 1982 sample of transformer oil indicate that the oil contained the PCB Aroclor 1260.

The power transformer unit was removed from the SWMU and decommissioned in 1997 (HES, 1997). The concrete pad, underlying the former power transformer was cleaned utilizing an enzyme solution specifically designed for PCB removal from concrete and metal surfaces. Soil samples were collected at the SWMU for analysis of PCB constituents. Low levels of PCBs were detected in shallow soil samples. Transformer-oil impacted gravel and soil were excavated, containerized, and removed from the SWMU.

Laboratory results from soil samples collected after the soil/gravel removal reported PCB concentrations below the method detection limits at the floor of the excavation (18 inches below surface grade).

Additional interim corrective action measures were not considered necessary at SWMU 28.

Building 5 USTs (Tanks B41-43)

The Building 5 tanks consisted of three USTs used to store fuel oil. Tanks B41 (15,000 gallons), B42 (15,000 gallons), and B43 (6,000 gallons) were each installed in 1941 and removed in 1988. The tanks were not replaced.

Building 6 USTs (Tanks B38 and B39)

The Building 6 tanks consist of 20,000-gallon double wall steel USTs used to store fuel oil to supply backup fuel to the power plant boilers. Tank B39 is active and Tank B38 has been closed in place.

5.3.2 Investigation Activities

A total of eight soil borings (four temporary shallow piezometers, one temporary deep piezometer, and three shallow soil borings only) were installed in Study Area F as part of the RFI. Five groundwater monitoring wells were installed in Study Area F during previous investigations. Ten soil samples, five piezometer groundwater samples and one groundwater monitoring samples were selectively analyzed for VOCs, TPHs, PCBs, PAHs, and metals.

5.3.3 Investigation Results

The Study Area F analytical results are presented in Tables 5-29 (soils), 5-30 (temporary piezometer groundwater, organics and inorganics), 5-31 (monitoring well groundwater, organics), and 5-32 (monitoring well groundwater, inorganics).

Soil

Xylene was detected at a low level in one (B4E1-14 at 9.4 µg/kg) of the 10 soil samples. The only other VOC detections in soil were low levels of common laboratory contaminants.

Detectable levels of TPH were reported for three of the five soil samples analyzed for TPH. The TPH fraction reported for each of these samples was DRO. The maximum level was reported for sample B4E2D-10, at 55,000 µg/kg, which is below the total TPH ITL.

PCBs were not detected in the two soil samples analyzed for PCBs. PAHs were detected at low levels in five of the seven soil samples analyzed for PAHs. None of the PAH levels exceeded the ITLs. The maximum level of PAHs were reported for the S10B4 3-5 soil sample, with phenanthrene at 56.7 µg/kg, dibenzo(a,h)anthracene at 46.5 µg/kg, and pyrene at 43.4 µg/kg. Eight of the soil samples were selectively analyzed for metals, with only one metal (arsenic at 12,000 µg/kg versus 11,000 µg/kg ITL) in one sample (S10B2 3-5) was reported above the ITL.

Groundwater

Three of the four Division F groundwater samples obtained from shallow temporary piezometers contained detectable levels of VOCs. None of these levels exceeded ITLs. Carbon disulfide and toluene were detected at 2.1 µg/L and 2.2 µg/L, respectively in the sample from B4E3. Naphthalene was detected at 4.2 µg /L in the sample from B5E2.

The DRO fraction of TPH was detected in four of the four shallow piezometer groundwater samples. The maximum level reported was 3,540 µg/L in the duplicate sample from B4E3. None of the temporary piezometer groundwater sample TPH levels exceeded the ITL.

PAHs were detected in the two shallow temporary piezometer groundwater samples analyzed for PAHs. Only one PAH (diethyl phthalate at 2.7 µg/L) was detected in the sample from B54E1. The sample from B5E2 contained 13 different PAHs at detectable levels. Three of these PAHs exceeded their respective ITLs: benzo(a)anthracene at 5.7 µg/L, benzo(b)fluoranthene at 5.3 µg/L, and chrysene at 6.7 µg/L. Two of the temporary piezometer groundwater samples were analyzed for total lead, but contained no detectable levels. The groundwater sample from B5E1 was analyzed for metals with detections of barium and zinc but at levels below ITLs.

The deep temporary piezometer groundwater sample (B4E2DW) did not contain detectable levels of BTEX, MTBE, or TPH.

The one Division F groundwater monitoring well (B5MW-22) was sampled twice for VOCs, and contained detectable but low levels of two VOCs, methylene chloride (a common laboratory contaminant) and 1,2-dichlorobenzene. The maximum level of 1,2-dichlorobenzene was reported at 3.7 µg/L. The monitoring well B5MW-22 was sampled once for TPH DRO and GRO. The TPH DRO fraction was detected in the sample from B5MW-22 at 520 µg/L, which is below the ITL.

A sample from B5MW-22 was analyzed for PAHs contained 7.8 µg/L of acenaphthene, which is below the ITL. A sample from B5MW-22 was analyzed for total/dissolved metals and contained total arsenic and lead exceeding their respective ITLs.

5.4 Study Area G – East Coldwater Creek

Study Area Division G is presented in Figure 5-14.

5.4.1 Area Description

SWMU 3 (Tank B40), Wastewater Sludge Collection and Holding Tank, Building 14

Unit SWMU 3 is a 120,000-gallon tank located outside of the IWTP in Building 14. The tank is used for holding sludge prior to dewatering. It is constructed of 12-inch steel reinforced concrete with straight sides and a conical bottom. There is a drain at the apex of the cone from which the sludge is pumped into a filter press for dewatering. The tank is 25 feet high from the drain. The diameter of the tank above the conical bottom is approximately 14 feet. The top of the tank extends 12 feet above natural grade, but an earthen mound encapsulates all but the upper 3 feet of the tank.

The operator pumps sludge through an underground piping system from settling tanks at the IWTP (SWMU 21) to this storage tank. When the tank becomes full, the plant operator pumps

the sludge into the centrifuge. The dewatered sludge is shipped offsite as hazardous waste. The water returns to the pretreatment plant.

The tank has been in operation since 1941. In 1988, the tank was drained for inspection, and cracks were observed in the wall of the tank. In November 1989, a 60 millimeter high-density polyethylene (HDPE) liner was installed on the inside of the tank. Other than installation of this liner, the tank has always been configured as it is today. Unit SWMU 3 stores wastewater treatment sludge that is a listed hazardous waste (F006 and F019 electroplating wastes).

SWMU 7, Explosive Waste Storage, Area 3 Building 10

Storage Area 3, located within Building 10, contained explosive waste used in military aircraft (e.g., gas generators, rocket motors, ammunition, etc.), as well as a small amount of raw explosive material (black powder, smokeless powder) used for research purposes. Building 10 is 20 feet wide by 40 feet long with a sealed concrete floor. Area 3 occupied a 12- by 20-foot area at the southern end of the building.

Storage of explosive waste in Area 3 was discontinued in December 1985. Closure of the unit was conducted in 1993 under the oversight of the MDNR HWP Permits section.

SWMU 21, IWTP Area

SWMU 21 consists of several IWTP sludge settling and equalization tanks. Principal components of the IWTP include aeration tanks, sludge settling tanks (S1 through S4), equalization tanks (E1 through E3), the sludge holding tank, and the filter press.

The IWTP was purchased from MSD, was converted for treatment of Boeing-specific wastewaters, and began operations in July 1970. Waste management activities at this unit involve the pretreatment of rinse water/overflows from chemical processing and electroplating operations. Hazardous waste codes assigned to the chemical processing solutions include D002, D004, D005, D006, D007, D008, and D010. Boeing continues to use the IWTP for wastewater treatment purposes.

The sludge settling and equalization tanks are in-ground, open top units and possess 4-inch reinforced concrete floors and 6-inch concrete walls. The tanks are connected in series from S1 through E3. The S-series tanks are settling tanks where sludge settles out and is separated from the water. The sludge from these tanks is pumped to the sludge collection tank. The E-series tanks are for pH adjustment (E-1) and additional settling.

Aircraft Shooting Range Bunker

This area is located at Building 13 was used to test aircraft cannons and the explosive devices used to release bombs from aircraft. Sand was used at the back of the gun range bunkers to collect the rounds. The bunker included three small test chambers and one large test chamber. No bullets reportedly penetrated the bunker walls into the soil mounds located behind the range.

The concrete rear walls of the bunkers were inspected and were not found to be damaged (Golder and Associates, 2003).

5.4.2 Investigation Activities

A total of 12 soil borings (seven completed as temporary piezometers) have been installed in Study Area G as part of the RFI. No groundwater monitoring wells are located in Study Area G. A total of 19 soil samples and seven groundwater samples obtained from the temporary piezometers were selectively sampled for VOCs, TPHs, PAHs, and metals.

5.4.2.1 Investigation Results

The analytical results for Study Area G samples are presented in Tables 5-33 (soils) and 5-34 (temporary piezometer groundwater, organics and inorganics).

Soil

Discounting acetone and methylene chloride as lab contaminants, only one of the Study Area G soil samples contained detectable levels of VOCs. Sample B10N1-12 was reported with 2.6 µg /kg of naphthalene, which is well below the ITL. Two of the five samples analyzed for TPH contained detectable levels of TPH. Sample B10N1-20 contained 2,520 µg/kg of TPH DRO but no detections of GRO fraction. The S21B5 10-12 sample contained 20093,000 µg /kg of DRO and 93,000 µg /kg GRO TPH, which exceeds the total TPH ITL of 200,000 µg/kg.

All 19 of the soil samples were analyzed for metals with two samples analyzed for lead only. Two metals (arsenic and selenium) exceeded ITLs. These exceedences, however, were sporadic, and no pattern was discerned. The arsenic ITL was exceeded in three samples, with a maximum level of 13,000 µg /kg, which is just slightly above the ITL of 11,000 µg/kg. The selenium ITL (4,300 µg/kg) was exceeded in one sample (B10N1-20) at 6,610 µg/kg.

Groundwater

No VOCs were detected in Study Area G temporary piezometer groundwater samples. The DRO fraction of TPH was detected in the three samples analyzed for TPH, but none exceeded the ITLs. The maximum TPH value detected was 629 µg/L in a sample from B10N1. One of the piezometer groundwater samples was analyzed for PAHs, but contained no detectable concentrations. Five of the groundwater samples were selectively analyzed for metals. The total arsenic level in two of the groundwater samples (B13E2W and B13E3W) exceeded the ITL (50 µg/L) with 55 µg/L and 62 µg/L respectively. The total chromium ITL (100 µg/L) was exceeded in one sample (S21B1W) at 170 µg/L. The corresponding dissolved chromium level for this sample was below detection limits. The total lead ITL (15 µg/L) was exceeded in three samples, with a maximum level of 750 µg/L in the sample from S21B1. The dissolved lead level for the sample from piezometer S21B1W, however, was below the detection limit.

6.0 Facility Wide Summary and Conclusions

This section of the report presents a site-wide summary of the RFI results per media (soil, groundwater) and per constituent group [inorganics (metals) and organics].

6.1 Summary of Metals Analysis

Analysis for inorganics (metals) was performed on soil and groundwater samples from across the Facility to determine if Facility operations had resulted in metal impacts. Metals are naturally occurring and are present in surficial geological material in varying concentrations. These natural variations in metal concentrations can make distinguishing natural versus manmade impacts difficult. For this reason, it is necessary to establish a range of background (or unimpacted) concentrations in soil of these naturally occurring metals. The range of background metal concentrations in Missouri based on the geometric mean of 1,140 samples collected in Missouri (10 from each of 114 counties) and the geometric mean of the 10 samples for selected metals from St. Louis County are presented in Table 6-1 (Tidball, 1984). The St. Louis County geometric mean is utilized as the background value. For those metals that the St. Louis County data was unavailable, the Missouri statewide geometric mean was used.

6.1.1 Soil Metals Analysis

As many as 143 soil samples collected as part of the RFI were analyzed for a specific metal (Table 6-2). The results of soil sampling indicated that only 20 soil samples from 17 soil borings contained metal concentrations above the respective ITLs (Table 6-3). Metals that were detected above ITL are summarized below:

Arsenic was detected above the ITL and St. Louis County background in 14 of the 120 soil samples analyzed for this metal. Most of the ITL exceedences were within 25 percent of the ITL. No pattern of arsenic ITL exceedences was apparent indicating that the observed concentrations are likely due to natural variations, not Facility operations. The two highest concentrations of arsenic detected in soil were from two adjacent soil borings, B27W1 and B27W3, located south of the scrap metal recycle dock and east of the hazardous waste storage shelter (SWMU 8). Soil samples collected from borings actually located within the recycle dock and SWMU 8, however, did not contain arsenic concentrations above the ITL. Again, this is likely due to natural variations, not Facility operations.

Beryllium was detected above ITLs in all five soil samples analyzed for this metal. However, all of the detections were below Missouri State background level for beryllium.

Chromium was detected above the ITL in two of the 121 soil samples analyzed for this metal. The two detections above ITLs were from two borings (B27I6 and B27E1). The soil samples

B27I6-8 and B27E1-9 contained 114,000 µg/kg and 69,800 µg/kg of chromium, respectively. These borings were located near the area of the industrial sewer line failure east of Building 27. Therefore, these exceedences may be related to Facility operations.

Selenium was detected above ITLs in two of the 120 soil samples analyzed for this metal. The maximum detection of 6,610 µg/kg (versus an ITL of 4,300 µg/kg) came from a depth of 20 feet bgs in boring B10N1. The soil sample collected from a depth of 12 feet bgs in boring B10N1, however, did not contain detectable concentrations of selenium. The other soil samples in which the selenium ITL was exceeded (B2N7-6) was also isolated, with no nearby samples containing elevated levels. Therefore, these exceedences are likely due to natural variations and not Facility operations.

Zinc exceeded the ITLs in all five samples analyzed for this metal. The five samples were from four borings (B2N6, B2N7, B5E1, and B10N1). Only two of these zinc detections, however, were above Missouri State background levels. Therefore, these exceedences are likely due to natural variations and not Facility operations.

6.1.2 Groundwater Metals Analysis

As many as 261 groundwater samples were collected from both monitoring wells and/or temporary piezometers ~~were~~ and analyzed for total metals (Table 6-4). Select groundwater samples were also analyzed for dissolved metals. Temporary piezometers used to collect groundwater samples from the low yielding shallow groundwater zone consisted of the installation of 1-inch piezometers within open boreholes (refer to Section 3.0 for sampling methodology). Field observations indicated that the groundwater samples from temporary piezometers were usually very turbid. After allowing time for the settling of sediment, it was common for 1/4 to 1/2 of a one liter sample jar to be sediment. A high level of sediment within the groundwater sample usually results in elevated total metal concentrations due to the inclusion of sediment containing the metal into the analysis. The USEPA methodology for total metal analysis requires the laboratory to agitate the sample immediately prior to extracting the sample for analysis.

Results of total metal analysis from temporary piezometers were generally higher than the results of total metal analysis from nearby monitoring wells. This can be observed in the total chromium results from Study Area C Division (3) presented on Figure 4-10 and Tables 4-16 and 4-18. At two locations at the Facility, groundwater monitoring wells were installed at the same location as temporary piezometers that had been sampled for total metals (MW5BS - B27E7 and MW5DS - B27E11). Five total metals (arsenic, barium, chromium, lead, and mercury) were above ITLs in the groundwater samples collected from these temporary piezometers. In the eight quarterly sampling events of these groundwater monitoring wells, no metals were detected above ITLs with the exception of one sample from MW5BS in which total lead was just above the ITL (19 µg/L versus the 15 µg/L ITL). The results of metal analysis for these temporary piezometers and monitoring wells are presented in Table 6-5.

Groundwater collected from monitoring wells showed a positive relationship between sediment content and total metal concentrations. Of the ~~29-24~~ monitoring wells at the Facility sampled ~~multiple more than twicetimes~~ for total metals, ~~19~~ had total metal results above ITLs during the ~~first sample event and~~ only ~~12~~^{six} had total metal results above ITLs following the first one or two sampling events (see Detections in Groundwater Monitoring Wells, Inorganic Analysis tables in Sections 4 and 5). This indicates that the first two sampling events conducted after installation of the well were likely affected by sediment in the same manner as observed for temporary piezometers. The subsequent sampling events produced less sediment due to settling and the removal of sediment during the purging of the well during sampling events, resulting in lower total metal levels. Of the 12 monitoring wells that had subsequent detections, eight had detections only one or two times and at concentrations just above the ITL. Only four (B25MW2, B28MW3, B28MW4, and MW9S) consistently had total metal detections above ITLs.

~~The six~~^{Six} wells that contained total metal detections above ITLs were also sampled for dissolved metals. Table 6-6 presents a comparison of the total to dissolved metal detections in subsequent (excluding after the first and second sampling events) sampling events ~~(in B25MW4, B28MW1, B28MW2, B28MW3, MW9S, and MW-A8)~~ are summarized in Table 6-6. The number of sampling events, the number of ITL exceedences, and a comparison to dissolved metal levels is provided in Table 6-6. Typically, the total metal ITL exceedences were not consistent between the sampling rounds, and the corresponding dissolved metal levels were significantly lower or non-detect. These observations indicate that the elevated total metal levels are not due to Facility operations, but due to variations in the sediment (colloidal particles) within the groundwater samples.

The only dissolved metal concentrations that exceeded the respective total metal ITLs are from the monitoring well MW9S groundwater samples. In these samples, the dissolved barium and the dissolved lead levels exceeded the respective ITL. Note that monitoring well MW9S did not contain detectable concentrations of VOCs in the 11 sampling events and it is not located near any known source of metal constituents (leaded gasoline, plating operations, etc.).

A statistical evaluation of total metals in groundwater was conducted by Jacobs Engineering using data collected from monitoring wells located on Boeing Tract 1 North (Jacobs, 2003). A total of four quarterly sampling events covering the time period of July 2000 and July 2001 were used to calculate if the concentrations detected in six downgradient wells (MW3, MW5, MW7, MW9S, MW10S, and B28MW2) was statistically different than in four upgradient wells (MW1, MW2, MW4, and MW-A8). The results of this analysis indicated that in almost all cases, there is no significant difference between the downgradient wells and the upgradient data. The only exceptions are for total barium and dissolved barium detected at MW9S in which a statistically significant difference was calculated between the downgradient well and upgradient wells for these two constituents. A copy of the statistical evaluation of metals in groundwater report is included in Appendix ~~H~~^K.

6.2 Organics

6.2.1 Soil Organics Analysis

As many as 32 soil samples collected as part of the RFI were selectively analyzed for organics (VOCs, TPHs, or PAHs). The organic constituents detected in soil samples which exceeded ITLs are presented in Table 6-7. Discounting methylene chloride as a laboratory contaminant, the principle organics exceeding ITLs were benzene (16 samples), total TPH (20 samples), PCE (8 samples), and TCE (6 samples). The PCE/TCE degradation (breakdown) products also exceeded ITLs in a few samples: cis-1,2-DCE (5 samples) and vinyl chloride (5 samples). There were only two PAHs [benzo(a)pyrene and chrysene] that exceeded ITLs, one time and four times, respectively.

The soil sample locations that exceeded the benzene, PCE/TCE/breakdown products, and TPH ITLs are presented in Figure 6-1. The soil benzene ITL exceedences are located in the study area Division E(1) in proximity to the jet fuel pipeline and to a former aviation gasoline fueling station/UST B68 and in Study Area E Division (5) near the UST fill station at the Building 41 tank farm. The assumed source of the benzene exceedences is jet fuel JP-4 which was stored in the USTs adjacent to Building 41 and transported in the jet fuel piping system to the fuel pits south of Buildings 45 and 42 and aviation gasoline stored in UST B68.

The TPH ITL exceedences are scattered across the Facility with isolated exceedences located in the study area Divisions C(2) at the scrap metal recycle dock and C(3) near machine equipment sumps. More extensive areas of TPH exceedences are located in the study area Divisions D(2), D(3), and E(1).

The PCE/TCE/breakdown product ITL exceedences were only observed in the study area Divisions C(2) (near the scrap metal recycle dock and SWMU 8) and D(2) (associated with SWMU 17).

6.2.2 Groundwater Organics Analysis

A total of up to 249 groundwater samples were selectively analyzed for organics (VOCs, TPHs, PCBs, and PAHs).

The organic constituents in groundwater that exceeded ITLs are presented in Table 6-8. The principle constituents that exceeded ITLs were TCE (45 sample locations), vinyl chloride (36 sample locations), PCE (27 sample locations), cis-1,2-DCE (28 sample locations), and benzene (25 sample locations). Various other PCE/TCE breakdown products exceeding ITLs were also reported for groundwater samples: total 1,2-DCE (11 sample locations), 1,1-DCE (8 sample locations), and trans-1,2-DCE (6 sample locations). The TPH ITL was exceeded at 41

sample locations and the MTBE ITL was exceeded at six sample locations. PAH ITLs were exceeded at three sample locations and the PCB Aroclor 1254 was exceeded at two sample locations. The TPH ITL was exceeded at 41 sample locations.

The benzene, PCB, PCE/TCE/breakdown products, and TPH ITL exceedences are presented in Figure 6-2. The groundwater benzene ITL was exceeded at one isolated sample location in the study area Division C(2) adjacent to UST B65 and the very western edge of D(2) extending west offsite onto airport property. The benzene ITL was also exceeded at several sample locations in study area Division E(1) along the jet fuel pipeline and at one location in Division E(2) by USTs B26 and B27. The benzene ITL was also exceeded in proximity to the UST fill station at the Building 41 tank farm in study area Division E(5).

PAH ITLs were exceeded in three of the 32 groundwater sample locations. These sample locations were all temporary piezometers (B22N1, RC2, B5E2). Note that PAHs as a class are extremely hydrophobic chemicals. Naphthalene is among the most water-soluble of the PAH, and its solubility in water is only about 30 mg/L. Solubility decreases with increasing molecular weight: chrysene (a four-ring PAH) and benzo[a]pyrene (a five-ring compound) are soluble in water in the low part per billion (mg/L) range. By comparison benzene, normally considered to be a water-immiscible chemical, has an aqueous solubility of about 2,000 mg/L. (Aitken et al., 1997). Because of the low solubility of PAHs, the detections of PAHs in these samples from temporary piezometers may be the result of sediment in the sample and not dissolved constituents as discussed for metal constituents in Section 6.1.2. Of the nine groundwater samples collected from monitoring wells and analyzed for PAHs, only one sample (B5MW-22W) contained a PAH detection, and that single PAH (acenaphthene) was below its ITL.

The PCB ITL was exceeded at two sample locations at the northern end of the Division C(2) study area at the scrap metal recycle dock.

The PCE/TCE/breakdown product groundwater ITLs were exceeded at several locations in study area Division C(2) and at two separate areas in Division C(3). These ITLs were exceeded at several locations within study area D, principally in Division D(2). There were also exceedences at isolated locations in study area Division E(5) and at one location in E(1).

The groundwater total TPH ITL was exceeded in only a few isolated locations on the North Tract in study area Divisions C(2) (scrap metal recycle dock) and C(3) (machining sumps). There were larger areas of TPH ITL exceedences on the South Tract in Study Area D [principally Divisions D(2) and D(3)] and in Study Area Division E(1) in proximity to the fuel pipelines, and at one location next to the former aviation gasoline fueling station/UST B68. The TPH ITL was also exceeded in Division E(2) in proximity to USTs B26 and B27 and at one isolated location in Division E(6) next to SWMU 24.

6.3 Groundwater Natural Attenuation Evaluation

Groundwater samples from selected monitoring wells and temporary piezometers were analyzed for parameters that can provide data regarding biodegradation activity in the shallow groundwater zone beneath the Facility. These parameters included total iron, dissolved iron, manganese, dissolved manganese, sulfate, sulfide, methane, chloride, total organic carbon, dissolved organic carbon, nitrate, nitrate-nitrite, ethane, and ethaneethene. Field measured parameters DO, pH, ORP and temperatures also provide data relevant to biodegradation activity.

As detailed in the 2001 Annual Monitoring Report for SWMU 17 (Harding ESE, 2002a) analytical results and field measurements for biodegradation parameters were used in an EPA screening protocol (USEPA, 1998) to evaluate the extent of any anaerobic biodegradation by reductive dechlorination that is occurring at SWMU 17. Results of the laboratory analysis for biological degradation indicator parameters are summarized in Appendix II. Copies of the laboratory reports of these analyses are included in Appendix EE. Results of field measured parameters are summarized in Appendix ED.

Monitoring wells MW-5I and MW-9S located in Study Area Division D(2), immediately downgradient of SWMU 17 exhibited biodegradation "scoring totals" of 17 and 16, respectively. These preliminary screening results indicate that adequate evidence exists that anaerobic biodegradation of chlorinated organics is at least occurring at these two locations. Monitoring well MW-7S, located at the presumed SWMU 17 release source, exhibited a scoring result of 10 which indicates that evidence of anaerobic biodegradation is limited at this location. However, this scoring total is likely to be conservatively low due to masking of VOC concentrations (e.g. daughter product concentrations at MW-7S due to significant PCE/TCE levels) and absence of data for other screening parameters (e.g., carbon dioxide, methane, etc.). There is inadequate evidence of anaerobic degradation at the Study Area Division D(1) where a low screening total of 5 was obtained for MW-8S. This result is expected since VOC levels at this location have been either very low and/or not detected.

Based on the results of this evaluation which indicated that biodegradation (reductive dechlorination) of chlorinated compounds was occurring at the Facility, a pilot test was implemented in June 2002 at the scrap metal recycle dock located in Study Area Division C(2). The pilot test consisted of the injection of 2,700±10 pounds of Hydrogen Release Compound® (HRC) in nine soil borings placed around monitoring well MW3 and monitoring the results in this well and two wells installed approximately 25 feet upgradient (MW3A) and downgradient (MW3B) of MW3. The results of the pilot test provide definitive evidence that reductive dechlorination is occurring within the test area and that the injection of HRC greatly accelerated the rate of chlorinated compound degradation. The dechlorination process was observed to go to completion with the reduction of TCE → cis-DCE → vinyl chloride → ethene → ethane (MACTEC, 2004). ~~are still being monitored, however, preliminary results indicate that significant~~

biodegradation of TCE and cis-1,2 DCE has occurred. Following completion of the pilot test, a report will be prepared documenting the test procedures and results.

6.4 Conclusions

Based on the results of the RFI, the RFA, and previous investigations conducted at the Facility, the following conclusions can be made:

- Impacts to soil and groundwater as the result of Facility activities have been identified, however, these impacts are confined to the Facility property and do not extend offsite or to cross from the North Tract to the South Tract or visa versa;
- The results of the RFI, RFA and previous investigations will be evaluated in a Facility Risk Assessment to determine if Corrective Measures are warranted at the Facility.

7.0 References

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Table 2 - 1 Summary of Underground Storage Tanks at Boeing Tract 1, Boeing Tract 1 RFI, Hazelwood, Missouri

Number	Building/Location	DNR Tank Registration	Regulated	Volume (gals)	Contents	Construction Materials	Year Installed	Status	Leak Detection	Remedial Actions
B1	Bldg. 41	N/A	Yes	4,000	T-979 Solvent	Single Wall Steel	1947	Removed 1981/not Replaced	N/A	Excavated
B2	Bldg. 41	N/A	Yes	4,000	Lacquer Thinner	Single Wall Steel	1947	Removed 1981/not Replaced	N/A	Excavated
B3	Bldg. 41	N/A	Yes	8,000	Aviation Gas	Single Wall Steel	1947	Removed 1981/Replaced	N/A	Excavated
B4	Bldg. 41	N/A	Yes	8,000	Gasoline	Single Wall Steel	1947	Removed 1981/Replaced	N/A	Excavated
B5	Bldg. 41	N/A	Yes	4,000	JP-5	Single Wall Steel	1981	Removed 1989/Replaced by F41	N/A	Excavated
B6	Bldg. 41	N/A	No	15,000	JP-4	Single Wall Steel	1947	Removed 1957/Replaced	N/A	Excavated
B7	Bldg. 41	N/A	No	15,000	JP-4	Single Wall Steel	1947	Removed 1957/Replaced	N/A	Excavated
B8	Bldg. 41	N/A	Yes	15,000	JP-4	Single Wall Steel	1948	Removed 1989/Replaced by A41	N/A	Excavated
B9	Bldg. 41	N/A	Yes	15,000	JP-4	Single Wall Steel	1948	Removed 1989/Replaced by B41	N/A	Excavated
B10	Bldg. 41	N/A	Yes	15,000	JP-4	Single Wall Steel	1957	Removed 1989/Replaced by C41	N/A	Excavated
B11	Bldg. 41	N/A	Yes	15,000	JP-4	Single Wall Steel	1957	Removed 1989/Replaced by D41	N/A	Excavated
B12	Bldg. 41	N/A	Yes	8,000	Gasoline	Fiberglass Reinforced Plastic	1981	Removed 1989/Replaced by E41	N/A	Excavated
B13	Bldg. 41	N/A	Yes	8,000	JP-5	Fiberglass Reinforced Plastic	1981	Removed 1989/Replaced by F41	Inventory Stick	Excavated
B14	Flight Operations/A-41	8027	No/Exempt	30,000	Jet Fuel	Double Wall Fiberglass	1989	Current	Interstitial Alarm	None
B15	Flight Operations/B-41	8027	No/Exempt	30,000	Jet Fuel	Double Wall Fiberglass	1989	Current	Interstitial Alarm	None
B16	Flight Operations/C-41	8027	No/Exempt	30,000	Jet Fuel	Double Wall Fiberglass	1989	Current	Interstitial Alarm	None
B17	Flight Operations/D-41	8027	No/Exempt	30,000	Jet Fuel	Double Wall Fiberglass	1989	Current	Interstitial Alarm	None
B18	Company Vehicles/E-41	8027	Yes	8,000	Gasoline	Double Wall Fiberglass	1989	Current	Interstitial Alarm	None
B19	Flight Operations/F-41	8027	No/Exempt	8,000	Water	Double Wall Fiberglass	1989	Current/Not in use	Interstitial Alarm	None
B20	Bldg. 1	N/A	No	500	Gasoline	Single Wall Steel	1956	Removed 1961/Not Replaced	N/A	Excavated
B21	Bldg. 1	N/A	No	500	Gasoline	Single Wall Steel	1961	Removed 1972/Not Replaced	N/A	Excavated
B22	Bldg. 1	8021	Yes	6,000	Diesel	Single Wall Steel	1972	Removed 1980/Not Replaced	N/A	Excavated
B23	Bldg. 1	8021	Yes	5,000	Gasoline	Single Wall Steel Relined in 1979	1941	Removed 1989/Not Replaced	Inventory Control	Excavated
B24	Bldg. 2	N/A	Yes	1,000	Gasoline/Diesel	Single Wall Coated Tar Epoxy Steel	1942	Removed 1989/Not Replaced	N/A	Excavated
B25	Bldg. 45	N/A	Yes	335	Diesel	Single Wall Steel	1958	Removed 1987/Not Replaced	N/A	Excavated
B26	Bldg. 45C/45D (Site #4)	N/A	Yes	3,380	Waste JP-4	Single Wall Steel	1963	Removed 1983/Not Replaced	N/A	Excavated
B27	Bldg. 45C/45D (Site #4)	N/A	Yes	3,380	Waste JP-4	Fiberglass Reinforced Plastic	1983	Removed 1989/Not Replaced	Inventory Stick	Excavated
B28	Bldg. 45E	N/A	Yes	2,130	Waste JP-4	Fiberglass Reinforced Plastic	1978	Removed 1990/Not Replaced	Inventory Stick	Excavated
B29	Bldg. 45, Fuel Pit #3 (Site #2)	N/A	Yes	2,000	Waste JP-4	Single Wall Steel	1977	Removed 1992/Not Replaced	Inventory Stick	Excavated/ Recovery Wells with closure 2002
B30	Bldg. 45, Fuel Pit #4 (Site #2)	N/A	Yes	2,000	Waste JP-4	Single Wall Steel	1983	Removed 1992/Not Replaced	Inventory Stick	Excavated/ Recovery Wells with closure 2002
B31	Bldg. 45K (Site #1)	N/A	Yes	4,380	Waste JP-4	Fiberglass Reinforced Plastic	1983	Removed 1993/Not Replaced	Inventory Stick	Excavated/Recovery Wells with closure 1999
B32	Bldg. 51	N/A	Yes	6,000	Solvents	Single Wall Steel	1977	Removed 1986/Not Replaced	Inventory Stick	Excavated
B33	Bldg. 43 Fuel Farm	UT0005886	Yes	20,000	Jet Fuel	Single Wall Steel	1957	Removed 1991/Not Replaced	Inventory Stick	Excavated total site of 799 cu yds
B34	Bldg. 43 Fuel Farm	UT0005886	Yes	20,000	Jet Fuel	Single Wall Steel	1957	Removed 1991/Not Replaced	Inventory Stick	Excavated total site of 799 cu yds
B35	Bldg. 43 Fuel Farm	UT0005886	Yes	20,000	Jet Fuel	Single Wall Steel	1957	Removed 1991/Not Replaced	Inventory Stick	Excavated total site of 799 cu yds
B36	Bldg. 43 Fuel Farm	UT0005886	Yes	20,000	Jet Fuel	Single Wall Steel	1957	Removed 1991/Not Replaced	Inventory Stick	Excavated total site of 799 cu yds
B37	Bldg. 43 Fuel Farm	UT0005886	Yes	20,000	Jet Fuel	Single Wall Steel	1957	Removed 1991/Not Replaced	Inventory Stick	Excavated total site of 799 cu yds
B38	Bldg. 6 (Boeing)	N/A	No/Exempt	20,000	Fuel Oil	Double Wall Steel/Plastic Coated	1989	Closed in Place	Inventory Control	No action
B39	Bldg. 6 (Boeing)	N/A	No/Exempt	20,000	Fuel Oil	Double Wall Steel/Plastic Coated	1989	Current	Inventory Control	No action
B40	Bldg. 14 (Boeing)	N/A	No/Exempt	120,000	Haz Waste Sludge	Concrete with Rubber Liner	1941	Current	Visual Inspection	No action
B41	Bldg. 5	N/A	No	15,000	Fuel Oil	Single Wall Steel	1941	Removed 1988	Visual Inspection	Excavated
B42	Bldg. 5	N/A	No	15,000	Fuel Oil	Single Wall Steel	1941	Removed 1988	Visual Inspection	Excavated
B43	Bldg. 5	N/A	No	6,000	Fuel Oil	Single Wall Steel	1941	Removed 1988	Visual Inspection	Excavated
B44	Bldg. 6	N/A	Yes	1,000	Waste Oil	Single Wall Steel	1970	Removed 1988	Visual Inspection	Excavated
B45	Bldg. 221	N/A	No	5,000	Fuel Oil	Single Wall Steel	1954	Removed 1990/Not Replaced	Visual Inspection	Excavated
B46A	Bldg. 33	N/A	Yes	300	Diesel	Single Wall Steel	1956	Removed 1990/Not Replaced	Visual Inspection	Excavated
B46	Bldg. 33	N/A	Yes	3,000	Diesel	Single Wall Steel	1960	Removed 1990/Not Replaced	Visual Inspection	Excavated
B47	Bldg. 33	N/A	No	20,000	Fuel Oil	Single Wall Steel	1956	Removed 1990/Not Replaced	Visual Inspection	Excavated
B48A	Bldg. 32	N/A	Yes	300	Gasoline	Single Wall Steel	1956	Removed 1990/Not Replaced	Visual Inspection	Excavated
B48	Bldg. 32	N/A	Yes	500	Gasoline	Single Wall Steel	1975	Removed 1990/Not Replaced	Visual Inspection	Excavated
B49	Bldg. 32	N/A	No	10,000	Fuel Oil	Single Wall Steel	1955	Removed 1990/Not Replaced	Visual Inspection	Excavated
B50	Bldg. 34	N/A	Yes	850	Diesel	Single Wall Steel	1957	Removed 1990/Not Replaced	Visual Inspection	Excavated
B51	Bldg. 34	N/A	No	10,000	Fuel Oil	Single Wall Steel	1957	Removed 1990/Not Replaced	Visual Inspection	Excavated
B52	Bldg. 22	N/A	Yes	5,000	Leaded Gasoline	Single Wall Steel	1942	Removed 1961 & Replaced	Visual Inspection	Excavated
B53	Bldg. 22	N/A	Yes	7,520	Leaded Gasoline	Single Wall Steel	1961	Removed 1989 & Replaced	Inventory Control	Excavated
B54	Bldg. 22	UT0008016	Yes	8,000	Unleaded Gasoline	Double Wall Fiberglass	1989	Retrofitted in 1995	Inventory Control	No action
B55	Bldg. 22	UT0008016	Yes	10,000	Unleaded Gasoline	Single Wall Fiberglass	1981	Removed in 1995 & Replaced	Inventory Control	Excavated
B56	Bldg. 22	UT0008016	Yes	10,000	Unleaded Gasoline	Double Wall Plastic Coated Steel	1995	Current	Interstitial Alarm	No action
B57	Bldg. 22	UT0008016	Yes	10,000	Diesel	Single Wall Fiberglass	1981	Removed in 1995 & Replaced	Inventory Control	Excavated
B58	Bldg. 22	UT0008016	Yes	10,000	Diesel	Double Wall Plastic Coated Steel	1995	Current	Interstitial Alarm	No action
B59	Bldg. 25	UT0005954	Yes	8,000	Methyl Alcohol	Single Wall Steel	1984	Removed in 1995/Not Replaced	Inventory Control	Excavated
B60	Bldg. 28	UT0008017	Yes	5,000	Jet Fuel	Single Wall Steel	1955	Removed in 1989 & Replaced	Inventory Control	Excavated
B61	Bldg. 28	UT0008017	Yes	5,000	Jet Fuel	Single Wall Steel	1955	Removed in 1989 & Replaced	Inventory Control	Excavated
B62	Bldg. 28	UT0008017	Yes	5,000	Waste Jet Fuel	Single Wall Steel	1953	Removed in 1989 & Replaced	Inventory Control	Excavated
B63	Bldg. 28	UT0008017	Yes	5,000	Jet Fuel	Double Wall Steel	1989	Removed in 2000/Not Replaced	Inventory Control	Excavated
B64	Bldg. 28	UT0008017	Yes	5,000	Jet Fuel	Double Wall Steel	1989	Removed in 2000/Not Replaced	Inventory Control	Excavated
B65	Bldg. 28	UT0008017	Yes	5,000	Waste Jet Fuel	Double Wall Steel	1989	Removed in 2000/Not Replaced	Inventory Control	Excavated/RCRA Corrective Action
B66	Bldg. 29	UT0008019	Yes	4,000	Hydraulic Oil	Single Wall Fiberglass	1980	Removed in 1994/Not Replaced	Visual Inspection	Excavated
B67	Bldg. 20	N/A	No	250	Fuel Oil	Single Wall Steel	1943	Removed in 1999/Not Replaced	Visual Inspection	Excavated
B68	Bldg. 42	N/A	No	Unknown	Aviation Gasoline	Single Wall Fiberglass	Unknown	Removed Date Unknown/ Not Replaced	Visual Inspection	Excavated

Notes:

DNR - Department of Natural Resources

Bldg - Building

gals - gallons

cu yds - cubic yards

N/A - Not Applicable

Bold - indicates the status of the tank is current

Table 2 - 3 RFI Study Area List with Associated SWMUs, Tanks, and Areas of Concern, Boeing Tract 1 RFI, Hazelwood, Missouri

Study Area	Potential Areas of Concern	Description and Status
A	Upgradient	Upgradient non-manufacturing/office portion of facility
B(1)	Building 220 Trash Compactor	Stained area adjacent to Trash Compactor hydraulic oil tank.
	Building 221 UST	B45 – 5,000-gallon fuel oil tank. Installed in 1954. Removed in 1990 and not replaced.
B(2)	Vapor Degreaser	Former vapor (TCE) degreaser. Installed in 1982. Removed in 1998 and not replaced.
C(1)	SWMU 29	Waste Ferracent, MEK and TCE drum storage. No further action required.
	Vapor Degreaser	Former vapor (TCE) degreaser in Building 29. Installed in 1981. Replaced 1992 with aqueous degreaser.
	Building 29A UST	B66 – 4,000-gallon hydraulic oil tank. Removed in 1994 and not replaced.
	Building 21	Maintenance Shop
C(2)	SWMU 4	Leaked or spilled jet aircraft fuel storage UST (B65)
	SWMU 5	Current reactive cyanide and sulfide bearing waste storage area (1977-2001).
	SWMU 6	Former reactive cyanide and sulfide bearing waste storage area (1989-1989).
	SWMU 8	Scrap Dock Shelter hazardous waste storage area near Building 39
	SWMU 31	Maintenance Shop waste oil AST
	SWMU 32	PCB Storage Building
	Scrap Recycle Dock Area	Scrap Metal Recycle Dock and oil water separator
	Building 22 USTs (Tanks B52-B58)	B52 – 5,000-gallon leaded gasoline tank. Installed in 1942. Removed in 1961 and replaced.
		B53 – 7,520-gallon leaded gasoline tank. Installed in 1961. Removed in 1989 and replaced.
		B54 – 8,000-gallon unleaded gasoline tank. Installed in 1989. Retrofitted in 1995.
		B55 – 10,000-gallon unleaded gasoline tank. Installed in 1981, removed and replaced in 1985.
		B56 – 10,000-gallon unleaded gasoline tank. Installed in 1995. Active.
		B57 – 10,000-gallon unleaded diesel tank. Installed in 1981. Removed and replaced in 1995.
	Building 28 USTs (Tanks B60-B65)	B58 – 10,000-gallon unleaded diesel tank. Installed in 1955. Active.
		B60 – 5,000-gallon jet fuel tank. Installed in 1955. Removed and replaced in 1989.
		B61 – 5,000-gallon jet fuel tank. Installed in 1955. Removed and replaced in 1989.
		B62 – 5,000-gallon waste jet fuel tank. Installed in 1953. Removed and replaced in 1989.
		B63 – 5,000-gallon jet fuel tank. Installed in 1989. Removed in 2000 and not replaced.
		B64 – 5,000-gallon jet fuel tank. Installed in 1989. Removed in 2000 and not replaced.
	Building 39	B65 – 5,000-gallon waste jet fuel tank. Installed in 1989. Removed in 2000 and not replaced.
C(3)	Building 39	Storage Building for unused hazardous material, Reception point for hazardous waste.
	SWMU 18	MEK/MIBK recovery unit in Building 27
	SWMU 30	Chemical etching spill containment area in Building 27
	Building 27 Machinery Pits	Numerous milling machinery pits containing aqueous cutting fluid and equipment
	Building 27 Aqueous Degreaser	Active aqueous degreaser at the northeast corner of Building 27
	Building 27 Vapor Degreaser	Small vapor (TCE) degreaser. Installed 1980s. Removed late 1990s.
	Building 27 Metal Plating Shop	Series of open top tanks above shallow collection basins, containing various acids
	Industrial Sewer	Industrial sewer east of Building 27
C(4)	Building 25 UST	B59 – 8,000-gallon Methyl Alcohol tank. Installed in 1984. Removed in 1995 and not replaced
	Building 20 UST	B67 – 250-gallon fuel oil tank. Installed in 1943. Removed in 1999 and not replaced
D(1)	Railroad	Adjacent to railroad property along north side of Banshee Road
D(2)	SWMU 2	Five 500-gallon nitric and hydrofluoric acid ASTs
	SWMU 9	Six 750-gallon nitric and hydrofluoric acid ASTs
	SWMU 15	One 4,380-gallon waste jet fuel UST (B31). Installed in 1983. Removed and not replaced 1993.
	SWMU 27	Waste nitric and hydroflouric acid scrubber, saddles drum storage
	Building 51 UST	B32 – 6,000-gallon solvent tank. Installed in 1977. Removed in 1986 and not replaced
D(3)	SWMU 1	Two sodium hydroxide ASTs
	SWMU 17	Two (750- and 350-gallon) PCE ASTs and a PCE distillation unit
	SWMU 25	Less than 90-day storage area near Building 51
E(1)	SWMU 16	MEK and MIBK distillant unit
	Fuel Oil ASTs	Former 15,000-gallon ASTs
E(2)	SWMU 14	Waste jet fuel storage UST (B29 and B30) at Fuel Pits 3 and 4
	Jet Fuel Hydrant System	Active and abandoned jet fuel underground piping
	Aviation Refueling Station	Former aviation gasoline refueling station and aviation gasoline UST (B68)
	Building 45 UST	B25 – 335-gallon diesel tank. Installed in 1958. Removed in 1987 and not replaced
E(3)	Building 43 Tank Farm	Five 20,000-gallon jet fuel USTs (B33 - B37). Installed 1951. Removed 1991.
	Building 45D	B26 – 3,380-gallon waste jet fuel tank. Installed in 1963. Removed in 1983 and replaced
	Building 45D	B27 – 3,380-gallon waste jet fuel tank. Installed in 1983. Removed in 1989 and not replaced
	SWMU 12	2,130-gallon waste jet fuel and hydraulic systems spillage UST (B28), F-18 silencer
	SWMU 13	Waste jet fuel and hydraulic systems spillage UST(B27) and oil water separator
E(4)	SWMU 23	Less than 90-day storage area Building 45C/45D
	Former SWMU 26	Less than 90-day storage area at Building 40
E(5)	Building 40	Maintenance Shop
E(6)	Industrial Sewer Line	
E(7)	Building 41	Storage building for drummed oils, solvents, and other chemicals.
	Building 41 UST Tank Farm (Tanks B1-B13)	Former and existing JP-4, JP-5, gasoline USTs
	SWMU 22	Paint booth satellite drum accumulation area at west side of Building 2
E(8)	Building 1 USTs (Tanks B20-B23)	B20 – 500-gallon gasoline tank. Installed in 1956. Removed in 1961 and replaced
		B21 – 500-gallon gasoline tank. Installed in 1961. Removed in 1972 and not replaced
		B22 – 6,000-gallon diesel tank. Installed in 1972. Removed in 1980 and not replaced
		B23 – 5,000-gallon gasoline tank. Installed in 1941. Removed in 1989 and not replaced
	Building 2 UST	B24 – 1,000-gallon diesel tank. Installed in 1942. Removed in 1989 and not replaced
F	SWMU 24	Less than 90-day storage area east of Building 2
	SWMU 10	Current waste oil AST at Building 5
	SWMU 11	1,000 gallon waste oil UST (B44) at Building 6. Installed in 1970. Removed in 1988
	SWMU 28	Leaking transformer removed in 1999
	Building 5 USTs (Tanks B41-43)	B41 – 15,000-gallon fuel oil tank. Installed in 1941. Removed in 1988
		B42 – 15,000-gallon fuel oil tank. Installed in 1941. Removed in 1988
		B43 – 6,000-gallon fuel oil tank. Installed in 1941. Removed in 1988
	Building 6 USTs (Tanks B38-39)	B38 – 20,000-gallon double wall steel fuel oil tank. Installed in 1989. Currently active
		B39 – 20,000-gallon double wall steel fuel oil tank. Installed in 1989. Closed in place
G	SWMU 3	Wastewater sludge collection and holding tank
	SWMU 21	Industrial Wastewater Treatment Plant tanks
	SWMU 7	Building 7, explosive waste storage, Area 3
	Aircraft Shooting Range Bunker	Building 13 Shooting Bunkers

Notes:

UST - Undergroiund storage tank
AST - Aboveground storage tank
SWMU - Solid Waste Management Unit
TCE - Trichloroethene

MEK - 2-Butanone
MIBK - Methyl Isobutyl Ketone
PCE - Tetrachloroethene

Table 2-4 Summary of Depth to Bedrock at Boeing Tract 1 and St. Louis Airport Site (SLAPS), Boeing Tract 1 RFI, Hazelwood, Missouri

Boring ID	Site	Date Installed	Well Type	Northing	Easting	Ground Elevation	Depth to Bedrock (ft bgs)	Bedrock Elevation (above msl)
MW10D	Boeing	9/22/2000	Deep Well	1,066,916	858,785	536.70	79.5	457.53
MW9D	Boeing	9/22/2000	Deep Well	1,066,226	858,007	536.17	70	466.50
MW5AD	Boeing	9/25/2000	Deep Well	1,065,786	858,972	531.22	78.5	453.05
MW-11D	Boeing	12/18/2000	Deep Well	1,065,129	856,987	547.08	75.3	472.11
B53W10D	SLAPS	1/25/1988	Deep Well	1,065,739	860,061	525.50	82.3	443.20
B53W11D	SLAPS	1/28/1988	Deep Well	1,065,065	862,190	536.10	79.8	456.30
B53G01	SLAPS	10/23/1987	Boring	1,066,989	861,081	520.00	79	441.00
B53G02	SLAPS	10/22/1987	Boring	1,066,871	861,654	519.00	79	440.00
B53G03	SLAPS	10/20/1987	Boring	1,066,693	861,338	519.30	79	440.30
B53G04	SLAPS	10/27/1987	Boring	1,066,676	861,741	516.70	79	437.70
B53G05	SLAPS	11/2/1987	Boring	1,066,650	860,501	518.90	84.2	434.70
B53G06	SLAPS	10/29/1987	Boring	1,065,765	859,803	522.10	80.3	441.80
B53G07	SLAPS	1/6/1988	Boring	1,066,412	862,783	525.80	76.3	449.50
B53G08	SLAPS	12/28/1987	Boring	1,066,110	862,360	530.40	78	452.40
B53G09	SLAPS	12/8/1987	Boring	1,066,064	861,769	529.80	80	449.80
B53G10	SLAPS	2/10/1988	Boring	1,065,992	861,272	528.00	76.3	451.70
B53G11	SLAPS	1/9/1988	Boring	1,065,906	862,143	532.00	79.7	452.30
B53G12	SLAPS	12/9/1987	Boring	1,065,907	862,751	522.00	73	449.00
B53G13	SLAPS	2/16/1988	Boring	1,065,914	860,719	526.50	94	432.50
B53G14	SLAPS	12/18/1987	Boring	1,065,748	861,838	531.00	80.7	450.30
B53G15	SLAPS	1/4/1988	Boring	1,065,722	862,438	528.80	75.5	453.30
B53G16	SLAPS	12/17/1987	Boring	1,065,444	862,320	532.80	83.8	449.00
B53G17	SLAPS	12/10/1987	Boring	1,065,410	862,715	524.20	75.7	448.50
B53G18	SLAPS	12/23/1987	Boring	1,066,435	862,272	529.40	81.2	448.20
B53W01D	SLAPS	11/18/1987	Deep Well	1,067,315	860,861	524.60	93.5	431.10
B53W02D	SLAPS	11/20/1987	Deep Well	1,066,897	862,134	515.10	81.9	433.20
B53W03D	SLAPS	11/12/1987	Deep Well	1,066,466	861,295	517.10	73	444.10
B53W04D	SLAPS	1/12/1988	Deep Well	1,066,494	861,995	528.72	81	447.72
B53W05D	SLAPS	11/9/1987	Deep Well	1,066,508	860,703	517.90	83.5	434.40
B53W06D	SLAPS	1/14/1988	Deep Well	1,066,337	861,470	526.36	77.4	448.96
B53W07D	SLAPS	1/23/1988	Deep Well	1,066,249	860,967	524.98	89	435.98
B53W08D	SLAPS	1/19/1988	Deep Well	1,066,129	860,559	524.20	91.7	432.50
B53W09D	SLAPS	2/29/1988	Deep Well	1,065,707	862,736	521.27	74.5	446.77
B53W12D	SLAPS	9/29/1992	Deep Well	1,065,221	862,388	527.60	78.2	449.40
M10-15D	SLAPS	7/22/1986	Deep Well	1,065,137	860,598	525.90	87.1	438.80
M10-8D	SLAPS	6/25/1986	Deep Well	1,065,176	859,909	519.42	73.5	445.92
PW-35	SLAPS	6/16/1999	Deep Well	1,064,959	862,692	526.10	87	439.10
MW8AD	Boeing	9/21/2000	Deep Well	1,065,941	858,933	534.35	81	453.35
MW6D	Boeing	9/23/2000	Deep Well	1,065,309	859,761	520.32	78	442.32
B45S1D	Boeing	11/18/2002	Boring	1,064,437	856,769	540.58	70	470.58
B45S5D	Boeing	11/18/2002	Boring	1,064,477	856,978	539.06	79	460.06
B45S5D	Boeing	11/18/2002	Boring	1,064,477	856,978	539.06	79.7	459.36
B4E2D	Boeing	11/22/2002	Boring	1,064,879	859,222	526.40	79.3	447.10
B45CS1D	Boeing	11/14/2002	Boring	1,064,151	857,013	537.30	79	458.30
B48S4D	Boeing	11/15/2002	Boring	1,064,800	857,108	537.72	76	461.72
B45S1D	Boeing	11/18/2002	Boring	1,064,437	856,769	540.58	73	467.58
B41E1D	Boeing	11/12/2002	Boring	1,065,079	857,813	535.43	72	463.43
B41S3D	Boeing	11/8/2002	Boring	1,064,994	857,712	534.03	70	464.03

Notes:

ft bgs - feet below ground surface
msl - mean sea level

**Table 2 - 7 Summary of Vertical Groundwater Gradients,
Boeing Tract 1 RFI, Hazelwood, Missouri**

	Well Pair	Water Elevation	Top of Screen Elevation	Gradient	Vertical Gradient Direction
Second Quarter 2003	SLAPS				
	None				
	Boeing				
	MW5AS	520.91	526.52	-0.0484	Upward
	MW5AD	523.99	462.82		
	MW6	510.97	511.47	-0.0286	Upward
	MW6D	512.66	452.32		
	MW9S	530.41	528.17	-0.1280	Upward
	MW9D	536.93	477.25		
	MW-10S	533.12	528.81	0.0157	Downward
	MW-10D	532.15	467.2		
	MW-11S	539.77	540.71	0.2424	Downward
	MW-11D	525.8	483.08		
Third Quarter 2003	SLAPS				
	B53W01S	509.84	527.00	-0.0715	Upward
	B53W01D	515.91	442.10		
	B53W02S	505.07	517.80	-0.0927	Upward
	B53W02D	511.82	445.00		
	B53W03S	501.30	518.90	-0.2421	Upward
	B53W03D	516.38	456.60		
	B53W04S	508.86	529.20	-0.0575	Upward
	B53W04D	512.74	461.70		
	B53W05S	503.87	520.50	-0.1702	Upward
	B53W05D	516.33	447.30		
	B53W06S	511.11	526.70	-0.0615	Upward
	B53W06D	514.78	467.00		
	B53W07S	507.22	526.90	-0.1071	Upward
	B53W07D	515.48	449.80		
	B53W08S	509.04	525.90	-0.0789	Upward
	B53W08D	515.51	443.90		
	M10-8S	509.87	521.70	-0.0655	Upward
	M10-8D	514.22	455.30		
	M10-15S	520.57	527.50	0.0689	Downward
	M10-15D	514.95	445.90		
	M10-25S	524.70	534.80	-0.0397	Upward
	M10-25D	526.31	494.20		
	Boeing				
	MW5AS	522.26	526.52	-0.0327	Upward
	MW5AD	524.34	462.82		
	MW6	508.45	511.47	-0.0776	Upward
	MW6D	513.04	452.32		
	MW8AS	523.32	527.36	-0.0201	Upward
	MW8AD	524.60	463.55		
	MW9S	530.30	528.17	-0.1642	Upward
	MW9D	538.66	477.25		
	MW-10S	532.86	528.81	0.0112	Downward
	MW-10D	532.17	467.20		
	MW-11S	541.15	540.71	0.2778	Downward
	MW-11D	525.14	483.08		

Table 2 - 8 Results of Geotechnical Laboratory Analysis, Boeing Tract 1 RFI, Hazelwood, Missouri

Well ID	Study Area	Date Collected	Sample Depth (ft bgs)	Moisture Content (%)	Dry Unit Weight (pcf)	Vertical Hydraulic Conductivity (cm/sec)	Description
MW5AD	C(3)	10/16/2000	29.0 - 30.0	20.7	105.2	1.4×10^{-5}	Gray-Brown Silty CLAY, CL
			75.0 - 76.0	15.4	116.5	1.2×10^{-8}	Light Gray-Brown CLAY, with Silt, CH
MW8AD	C(3)	10/16/2000	39.0 - 41.0	30.1	93.6	5.4×10^{-7}	Gray-Brown Silty CLAY, CL
			64.0 - 66.0	20.5	104.1	2.7×10^{-7}	Gray-Brown Silty CLAY, CL/CH
MW8AS	C(3)	10/16/2000	10.0 - 12.0	28.1	95.2	3.1×10^{-4}	Gray SILT, ML
MW-11S	D(3)	1/15/2001	9.0 - 11.0	28	95.3	7.1×10^{-6}	Gray-Brown Clayey SILT, ML/CL
MW-11I	D(3)	1/15/2001	36.0 - 38.0	27.1	100.9	5.4×10^{-6}	Gray-Brown Silty CLAY, CL
MW-11D	D(3)	1/15/2001	59.0 - 60.0	18.5	108.4	1.1×10^{-9}	Light Gray Clayey SHALE, CH

Notes:

ft bgs - feet below ground surface
% - Percent

pcf - pounds per cubic foot
cm/sec - centimeters per second

Table 2 - 9 Summary of Hydraulic Conductivity and Transmissivity Values, Boeing Tract 1 RFI, Tract 1 RFI, Hazelwood, Missouri

Method	Well ID	RFI Well ID	Study Area	Screened Interval (ft bgs)	Transmissivity (T) (cm ² /sec)	Hydraulic Conductivity (K) (cm/sec)
Pump Test ^a	MW-7S	MW-7S	D(2)	3 - 15	1.17E-01	2.21E-04
	MW-7S	MW-7S	D(2)	3 - 15	1.27E-01	2.39E-04
	TP-1	TP-1	D(2)	6.5 - 12.5	4.89E-03	9.32E-06
	TP-5	TP-5	D(2)	6 - 16	1.90E-02	3.62E-05
	TP-17	TP-17	D(2)	6 - 16	4.62E-02	8.80E-05
Slug Test ^b	MW-10	B4MW-10	F	2 - 12	9.90E-03	4.70E-05
	MW-22	B5MW-22	F	4.6 - 14.6	1.30E-02	7.60E-05
	MW-15	B28MW-15	C(2)	2 - 12	1.40E-02	9.30E-05
	MW-16	B28MW-16	C(2)	2 - 12	9.20E-03	8.40E-05
	MW-17	B41MW-17	E(5)	2 - 12	3.20E-03	2.10E-05
	MW-20	B41MW-20	E(5)	2 - 12	6.70E-02	6.10E-06
Slug Test ^c	MW-A8	MW-A8	D(1)	2.5 - 12.5	--	9.14E-06
	MW-A9	MW-A9	E(1)	4.5 - 14.5	--	2.10E-05
	MW-A3	MW-A3	E(2)	5 - 15	--	1.38E-05
Geometric Mean					2.02E-02	3.83E-05

Notes:

^a Harding ESE, 2002

^b Burns & McDonnell, 1989

^c ATEC, 1990

-- - not calculated

cm²/sec - centimeters squared per second

cm/sec - centimeters per second

ft bgs - feet below ground surface

Table 5 - 12 Detections in Groundwater, Boeing Tract 1 RFI Organic Analysis, Monitoring Wells in Study Area Division D(3) (Page 1 of 2)

Sample ID		Collection Date	Units	Volatile Organic Compounds (VOCs)																		TPH					
				1,1-DICHLOROETHANE	1,2,3-TRIMETHYLBENZENE	1,2,4-TRIMETHYLBENZENE	1,2-DICHLOROPROPANE	BENZENE	BROMOMETHANE	CIS-1,2-DICHLOROETHENE	ETHYLBENZENE	ISOPROPYL BENZENE	METHYL TERT-BUTYL ETHER (MTBE)	NAPHTHALENE	N-BUTYLBENZENE	N-PROPYLBENZENE	P-ISOPROPYLTOLUENE	SEC-BUTYLBENZENE	TERT-BUTYLBENZENE	TETRACHLOROETHENE (PCE)	TOLUENE	TRICHLOROETHENE (TCE)	VINYL CHLORIDE	XYLENES, TOTAL	TPH (DRO)	TPH (GRO)	Total TPH
Shallow Wells	B48N1W	11/11/2002	µg/L	< 5	NA	< 5	< 5	< 5	< 5	< 5	< 5	NA	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	NA	< 1,000	NA	< 1,000	
		12/11/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	14	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 3	110	NA	110	
		3/21/2003	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	30	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 3	480	NA	480	
		6/27/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	59	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 3	170 J	< 100	170 J	
	MW-9S	2/21/2001	µg/L	< 1	NA	< 1	< 1	6	< 1	< 1	< 1	7.6	< 1	< 1	< 1	11	< 1	3.6	< 1	< 1	1.2	< 1	< 1	5.2	2,400	< 100	2,400
		7/27/2001	µg/L	< 1	NA	< 1	< 1	3.9	< 1	< 1	< 1	4.4	< 1	< 1	3.9	5.2	1.5	2	< 1	< 1	< 5	1.2	< 1	< 3	6,300	NA	6,300
		10/30/2001	µg/L	< 1	NA	< 1	< 1	5.2	< 1	1.3	1.4	3.5	< 1	< 1	2.7	3.8	4.2	2.8	3.2	< 1	< 5	< 1	< 1	4.1	6,100	NA	6,100
		12/19/2001	µg/L	< 50	NA	< 50	< 50	51	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 250	52	< 50	< 150	6,700 J	NA	6,700 J	
		3/5/2002	µg/L	< 1	NA	< 1	< 1	3.2	< 1	< 1	< 1	2.9	< 1	< 5	2	3.5	2	2.6	< 1	< 1	< 5	< 1	< 1	< 3	5,300	NA	5,300
		5/30/2002	µg/L	< 50	NA	< 50	< 50	< 50	< 50	2,400	< 50	< 50	< 50	< 250	< 50	< 50	< 50	< 50	< 50	6,900 E	< 250	3,800 E	55	< 150	5,400	NA	5,400
		8/8/2002	µg/L	< 25	NA	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 120	< 25	< 25	< 25	< 25	< 25	< 120	460	< 25	< 75	2,900	NA	2,900	
		12/11/2002	µg/L	< 1	NA	1.8	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	1.4	< 1	< 1	< 5	< 1	< 1	< 3	3,500	NA	3,500
	3/21/2003	µg/L	< 1	NA	< 1	< 1	4.6	< 1	< 1	< 1	2.7	< 1	< 5	1.5	2.9	1.8	2.2	< 1	< 1	< 5	< 1	< 1	< 3	6,400	NA	6,400	
	6/27/2003	µg/L	< 1	< 1	< 1	< 1	4	< 1	< 1	< 1	2.3	< 1	< 5	2	2.9	< 1	1.5	< 1	< 1	< 5	< 1	< 1	< 3	2,000 J	< 100	2,000 J	
	MW-9S Dup	7/27/2001	µg/L	< 1	NA	< 1	< 1	3.6	< 1	< 1	< 1	4	< 1	1.4	2.6	4.1	1.2	1.7	< 1	< 1	< 5	1	< 1	< 3	5,500	NA	5,500
		10/30/2001	µg/L	< 1	NA	< 1	< 1	5	< 1	1.3	1.4	3.7	< 1	< 1	2.2	4.4	4.3	3.3	3.2	< 1	< 5	< 1	< 1	4.3	6,300	NA	6,300
		12/19/2001	µg/L	1.1	NA	< 1	< 1	4	< 1	1.4	1.6	6.3	< 1	< 1	5.3 J	7.4	4.4	5.4	1.9	< 1	< 5	< 1	< 1	5.5	6,300 J	NA	6,300 J
		3/21/2003	µg/L	< 1	NA	< 1	< 1	5.1	< 1	< 1	< 1	3	< 1	< 5	1.8	3.4	1.9	2.4	< 1	< 1	< 5	< 1	< 1	< 3	6,200	NA	6,200
	MW-10S	2/20/2001	µg/L	< 1	NA	< 1	< 1	< 0.5	< 1	< 1	< 0.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.5	< 1	< 1	< 1.5	950	< 100	950
		7/27/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	7,600	NA	7,600
		10/29/2001	µg/L	< 1,000	NA	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 3,000	3,600	< 1,000	< 1,000	2,100	< 1,000	< 1,000	< 5,000	< 1,000	< 1,000	< 3,000	300,000	NA	300,000
		12/19/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	2.7	< 1	< 1	< 1	4	< 1	8.5	< 1	< 1	< 5	< 1	< 1	< 3	330,000 J	NA	330,000 J
		3/5/2002	µg/L	< 5	NA	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 25	< 5	9.3	6.4	8.1	< 5	< 5	< 25	< 5	< 5	< 15	74,000	NA	74,000
		6/3/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	140,000	NA	140,000
	6/17/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	48,000	< 100	48,000	
	MW-11S	2/20/2001	µg/L	< 1	NA	< 1	< 1	< 0.5	< 1	< 1	< 0.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.5	< 1	< 1	< 1.5	< 100	< 100	< 100
		7/25/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	19	< 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	8.9	< 1	< 3	< 100	NA	< 100
		10/29/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 3	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100
12/17/2001		µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
3/5/2002		µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
6/3/2002		µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	1.5	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
8/13/2002		µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
12/5/2002		µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
3/12/2003	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100		
6/17/2003	µg/L	< 1	28	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	13	3.6	< 1	< 5	< 1	< 1	< 3	< 100	1,400	< 100	1,400	
Investigation Threshold Level (ITL)			µg/L	4,000	--	12	5	5	--	70	700	--	20	100	61	61	--	61	--	5	150	5	2	320	--	--	10,000 (1)

Notes:

TPH - Total Petroleum Hydrocarbons
DRO - Diesel range organics
GRO - Gasoline range organics
µg/L - micrograms per liter
< - Constituent not detected above this value
(1) - Total TPH

NA - Not Analyzed
J - Estimated value
B - Constituent found in blank
R - Rejected result value
-- - ITL has not been determined for this constituent

Shading represents detections of constituents above the project ITL value.

Table 5 - 12 Detections in Groundwater, Boeing Tract 1 RFI Organic Analysis, Monitoring Wells in Study Area Division D(3) (Page 2 of 2)

Sample ID		Collection Date	Units	Volatile Organic Compounds (VOCs)																				TPH			
				1,1-DICHLOROETHANE	1,2,3-TRIMETHYLBENZENE	1,2,4-TRIMETHYLBENZENE	1,2-DICHLOROPROPANE	BENZENE	BROMOMETHANE	CIS-1,2-DICHLOROETHENE	ETHYLBENZENE	ISOPROPYL BENZENE	METHYL TERT-BUTYL ETHER (MTBE)	NAPHTHALENE	N-BUTYLBENZENE	N-PROPYLBENZENE	P-ISOPROPYLTOLUENE	SEC-BUTYLBENZENE	TERT-BUTYLBENZENE	TETRACHLOROETHENE (PCE)	TOLUENE	TRICHLOROETHENE (TCE)	VINYL CHLORIDE	XYLENES, TOTAL	TPH (DRO)	TPH (GRO)	Total TPH
Shallow Wells	TP-3	2/6/1998	µg/L	< 5	NA	NA	< 5	< 5	< 10	< 5	< 5	NA	NA	NA	NA	NA	NA	NA	NA	< 5	< 5	< 5	< 10	< 5	NA	NA	NA
		2/23/2001	µg/L	< 100	NA	330	< 100	680	< 100	< 100	200	< 100	1,400	540	< 100	< 100	< 100	< 100	< 100	< 100	1,200	< 100	< 100	1,200	45,000	21,000 E	66,000 E
		7/25/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 2	4.7	< 1	< 1	< 1	4.2	< 1	10	< 1	< 1	< 5	< 1	< 1	< 3	7,400	NA	7,400
		10/29/2001	µg/L	< 1	NA	1.6	< 1	< 1	< 1	< 1	< 1	3.6	< 1	< 3	12	3.5	2.2	6.1	< 1	< 1	< 5	< 1	< 1	< 3	6,900	NA	6,900
		12/19/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	3.4	< 1	< 1	12	3.2	2.9	8.4	< 1	< 1	< 5	< 1	< 1	< 3	15,000 J	NA	15,000 J
		3/5/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	5.3	< 1	< 5	10	4.3	< 1	9.9	< 1	< 1	< 5	< 1	< 1	< 3	8,800	NA	8,800
		5/30/2002	µg/L	< 100	NA	< 100	< 100	< 100	< 100	1,900	< 100	< 100	< 100	< 500	< 100	< 100	< 100	< 100	< 100	7,100 E	< 500	4,800	< 100	< 300	9,800	NA	9,800
		8/8/2002	µg/L	< 200	NA	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 1,000	< 200	< 200	< 200	< 200	< 200	< 200	< 1000	5,300	< 200	< 600	7,500	NA	7,500
		12/9/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	1.9	< 1	< 5	4	1.7	1.1	2.4	< 1	< 1	< 5	< 1	< 1	< 3	9,100	NA	9,100
		3/19/2003	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	13,000	NA	13,000
	6/27/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.2	< 1	< 5	5.6	2.9	< 1	4.6	< 1	< 1	< 5	< 1	< 1	< 3	5,900 J	21,000 E	26,900 EJ	
	TP-6	9/5/2001	µg/L	< 1,000	NA	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 5,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 5,000	< 1,000	< 1,000	< 3,000	230,000	< 10,000	230,000
		12/18/2001	µg/L	< 100	NA	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 500	2,900	< 100	< 300	20,000 J	NA	20,000 J
		3/5/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	4,300	NA	4,300	
		6/3/2002	µg/L	< 1	NA	1.2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	2.4	2.2	< 1	< 1	< 5	1.9	< 1	< 3	2,800	NA	2,800
		8/13/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	1.5 J	< 1	1.1 J	1.6 J	< 1	< 1	< 5	< 1	< 1	< 3	2,700 J	NA	2,700 J
		12/5/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	1.4	< 1	< 1	< 5	< 1	< 1	< 3	2,500	NA	2,500
	TP-6 Dup	3/18/2003	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	1	< 1	1.1	1.3	< 1	< 1	< 5	< 1	< 1	< 3	1,600	NA	1,600
		6/17/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	1	1	< 1	< 1	< 5	< 1	< 1	< 3	1,300	< 100	1,300
Deep Wells	MW-111	2/19/2001	µg/L	< 1	NA	< 1	< 1	< 0.5	< 1	< 1	< 0.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.5	< 1	< 1	< 1.5	< 100	< 100	< 100	
		7/26/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
		10/26/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 2	< 1	< 3	< 100	NA	< 100	
		12/17/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
		3/5/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
		6/3/2002	µg/L	< 1	NA	< 1	2	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	140	NA	140	
		8/13/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
		12/9/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	12	< 1	< 3	< 100	NA	< 100	
	3/18/2003	µg/L	< 1	NA	< 1	< 1	< 1	1.2 J	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100		
	6/25/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	< 100	< 100		
	MW-111 Dup	8/13/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100	
		3/18/2003	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	NA	NA	NA	
	6/25/2003	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	< 100	< 100	
MW-11D	2/19/2001	µg/L	< 1	NA	< 1	< 1	< 0.5	< 1	< 1	< 0.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.5	< 1	< 1	< 1.5	< 100	< 100	< 100		
	7/26/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 3	< 100	NA	< 100		
	10/26/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	17	< 1	< 3	< 100	NA	< 100		
	12/17/2001	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	1.3	< 1	< 3	< 100	NA	< 100		
	3/5/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	1	< 1	< 3	< 100	NA	< 100		
	6/3/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	5.2	< 1	< 3	< 100	NA	< 100		
	8/13/2002	µg/L	< 1	NA	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 5	1.1</							

Notes:

TPH - Total Petroleum Hydrocarbons
DRO - Diesel range organics
GRO - Gasoline range organics
µg/L - micrograms per liter
< - Constituent not detected above this value
(1) - Total TPH

NA - Not Analyzed
J - Estimated value
B - Constituent found in blank
R - Rejected result value
-- - ITL has not been determined for this constituent

Shading represents detections of constituents above the project ITL value.

Table 5 - 13 Detections in Soil, Boeing Tract 1 RFI Organic and Inorganic Analysis, in Study Area Division E(1) (Page 1 of 2)

Parameters	Units	B42E1-5	B42E2-8	B42E3-4	B42N1-9	B42N2-12	B42N3-4	B42N4-8	B42N5-6	B42S1-6	B42S2-5	B42S3-9	B42S4-6	B42S5-8	B42S6-5	B42S7-8	B42W1-5	B45S2-7	B45S2-7 Dup	B45S3-7	Investigation Threshold Level (ITL)	
		7/1/2003	7/22/2003	7/22/2003	7/1/2003	7/23/2003	7/23/2003	7/23/2003	7/23/2003	11/19/2002	6/30/2003	7/22/2003	7/22/2003	7/22/2003	7/22/2003	7/23/2003	6/30/2003	11/18/2002	11/18/2002	11/18/2002		
Volatile Organic Compounds (VOCs)																						
Acetone	µg/kg	NA	< 20	19 J	NA	< 20	< 20	< 20	< 100	NA	NA	< 20	< 20	42 J	44	< 20	NA	NA	NA	NA	1,600,000	
Benzene	µg/kg	1,170	34.8	107	< 50	< 2	< 2	< 2	< 10	< 2.5	76	< 2	< 2	63.5	< 2	< 2	< 50	601	549	242	50	
Carbon Disulfide	µg/kg	NA	< 10	3 J	NA	< 10	< 10	< 10	< 50	NA	NA	< 10	< 10	< 50	< 10	< 10	NA	NA	NA	NA	360,000	
Ethylbenzene	µg/kg	< 50	110	2.6	< 50	< 2	< 2	< 2	91	< 2.5	< 50	< 2	< 2	< 10	< 2	< 2	< 50	< 5,000	< 50	< 50	32,000	
Isopropyl Benzene	µg/kg	NA	< 5	4 J	NA	< 5	< 5	< 5	80	NA	NA	< 5	< 5	47	< 5	< 5	NA	NA	NA	NA	160,000	
Methyl Tert Butyl Ether (MBTE)	µg/kg	< 25	< 10	< 2	< 25	< 2	< 2	< 2	< 10	< 25	< 25	< 2	< 2	30	< 2	5.8	< 25	< 50	< 50	< 50	67	
Methylene Chloride	µg/kg	NA	< 20	< 20	NA	5.3 J	5.4 J	5.6 J	29 J	NA	NA	< 20	< 20	< 100	< 20	5.4 J	NA	NA	NA	NA	20	
N-Butylbenzene	µg/kg	NA	< 5	< 5	NA	< 5	< 5	< 5	< 25	NA	NA	< 5	< 5	59	5.7	< 5	NA	NA	NA	NA	140,000	
N-Propylbenzene	µg/kg	NA	< 5	2.9 J	NA	< 5	< 5	< 5	110	NA	NA	< 5	< 5	84	< 5	< 5	NA	NA	NA	NA	28,000	
Sec-Butylbenzene	µg/kg	NA	9.7	5.7	NA	< 5	< 5	< 5	91	NA	NA	< 5	< 5	62	6.9	< 5	NA	NA	NA	NA	110,000	
T-Butylbenzene	µg/kg	NA	< 5	< 5	NA	< 5	< 5	< 5	< 25	NA	NA	< 5	< 5	12 J	< 5	< 5	NA	NA	NA	NA	130,000	
Toluene	µg/kg	398	28	8.6	< 50	3.1	2.6	2.6	23	< 25	452	< 2	< 2	41	4.2	2.7	< 50	3,200	2,930	1,550	3,700	
Xylenes (Total)	µg/kg	731	58	58	< 50	5.4	6.7	< 5	64	< 7.5	225	< 5	< 5	310	42	< 5	< 50	360	263	328	16,000	
Total Petroleum Hydrocarbons (TPH)																						
TPH (DRO)	µg/kg	< 5,000	29,960	< 6,242	NA	< 6,444	< 6,450	< 6,275	9,510	< 4,000	966,000	< 6,364	< 6298	5,320	399,000	< 6,553	94,000	< 5,000	< 5,000	< 5,000	--	
TPH (GRO)	µg/kg	311,000	11,800	29,200	NA	< 1,000	< 1,000	< 1,000	6,540	< 500	54,000	< 1,000	< 1,000	38,100	3,700	< 1,000	< 5,000	186,000	163,000	206,000	--	
Total TPH	µg/kg	311,000	41,760	29,200	NA	< 6,444	< 6,450	< 6,275	16,050	< 4,000	1,020,000	< 6,364	< 6298	43,420	402,700	< 6,553	94,000	186,000	163,000	206,000	200,000 (1)	
Metals (Total)																						
Lead	µg/kg	NA	10,200	14,600	NA	11,200	8,690	8,460	7,120	NA	NA	11,600	9,400	8,800	12,000	10,900	NA	NA	NA	NA	260,000	

Notes:

µg/kg - micrograms per kilogram
DRO - Diesel range organics
GRO - Gasoline range organics
< - Constituent not detected above this value
(1) Total TPH
Shading represents detections of constituents above the project ITL value.

NA - Not Analyzed
J - Estimated value
-- - ITL has not been determined for this constituent

Table 5 - 13 Detections in Soil, Boeing Tract 1 RFI Organic and Inorganic Analysis, in Study Area Division E(1) (Page 2 of 2)

Parameters	Units	B45S4-7	B45S6-6	B45S7-7	B45S8-6	B45S9-6	B45S10-6	B45S11-6	B45S12-6	B48S1-6	B48S2-5	B48S3-10	B48S5-6	B48S6-6	B48S7-7	B48S8-7	B48S9-8	B48S10-7	B48S11-3	Investigation Threshold Level (ITL)
		11/18/2002	11/18/2002	11/18/2002	11/19/2002	11/19/2002	11/19/2002	6/30/2003	6/30/2003	11/14/2002	11/15/2002	11/15/2002	11/19/2002	11/19/2002	11/20/2002	11/20/2002	11/21/2002	11/21/2002	6/30/2003	
Volatile Organic Compounds (VOCs)																				
Acetone	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,600,000
Benzene	µg/kg	< 50	< 50	< 50	< 50	< 50	62	293	< 50	307	< 50	98	57	< 50	< 50	125	< 2.5	< 2.5	< 50	50
Carbon Disulfide	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	360,000
Ethylbenzene	µg/kg	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	227	< 50	346	< 50	< 50	< 50	408	< 2.5	< 2.5	< 50	32,000
Isopropyl Benzene	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	160,000
Methyl Tert Butyl Ether (MBTE)	µg/kg	< 50	< 50	< 50	< 50	< 50	< 50	< 25	< 25	< 50	< 50	< 50	< 50	< 50	< 50	< 50	NA	NA	< 25	67
Methylene Chloride	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20
N-Butylbenzene	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	140,000
N-Propylbenzene	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	28,000
Sec-Butylbenzene	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110,000
T-Butylbenzene	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	130,000
Toluene	µg/kg	< 50	< 50	67	< 50	< 50	952	2,500	< 50	3,000	< 50	52	354	< 50	76	1,090	< 25	< 25	< 50	3,700
Xylenes (Total)	µg/kg	< 50	< 50	113	< 50	< 50	513	463	< 50	829	< 50	254	670	< 50	273	461	< 7.5	< 7.5	< 50	16,000
Total Petroleum Hydrocarbons (TPH)																				
TPH (DRO)	µg/kg	< 5,000	< 5,000	< 5,000	< 5,000	< 5,000	< 5,000	992,000	127,000	47,000	< 5,000	< 5,000	< 5,000	< 5,000	< 5,000	< 5,000	38,000	38,000	1,364,000	--
TPH (GRO)	µg/kg	12,000	< 5,000	68,000	21,000	< 5,000	103,000	154,000	< 5,000	250,000	< 5,000	83,000	66,000	< 5,000	38,000	133,000	NA	NA	13,000	--
Total TPH	µg/kg	12,000	< 5,000	68,000	21,000	< 5,000	103,000	1,146,000	127,000	297,000	< 5,000	83,000	66,000	< 5,000	38,000	133,000	38,000	38,000	1,377,000	200,000 (1)
Metals (Total)																				
Lead	µg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	260,000

Notes:

- µg/kg - micrograms per kilogram

DRO - Diesel range organics

GRO - Gasoline range organics

< - Constituent not detected above this value

(1) Total TPH

Shading represents detections of constituents above the project ITL value.
- NA - Not Analyzed

J - Estimated value

-- - ITL has not been determined for this constituent





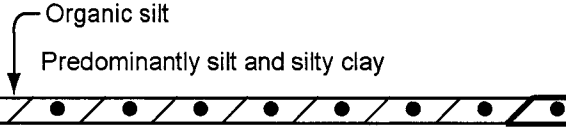






System	Formation/Group	Approximate Thickness	Dominant Lithology
Pennsylvanian	Marmaton Group	~ 80'	Shale, siltstone, coal & limestone
	Cherokee Group	~ 75'	Shale, siltstone, coal & limestone
Mississippian	Ste. Genevieve Formation	~30'	Sandy limestone
	St. Louis Limestone	~80'	Limestone
	Salem Formation	~120'	Limestone & shale
	Warsaw Formation	~75'	Shale with limestone
	Burlington-Keokuk Limestone	~120'	Cherty limestone
	Fern Glen	~40'	Red limestone & shale
Ordovician	Maquoketa Group	~100'	Shale – acts as confining unit or aquitard, limestone & sandstone

Drawn by: SEG Approved By:
Checked by: LMS Date: 5/8/04



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Figure 2-6
Generalized Bedrock Stratigraphic
Column for the St. Louis Region,
Boeing Tract 1 RFI, Hazelwood, Missouri

Period	Stratigraphy	Thickness	Description	Boeing Groundwater Zones	SLAPS Groundwater Zones
 Quaternary 	Fill/topsoil	0-10'	Clay, silt, bricks, wood	 Shallow groundwater 	H2-A
	Loess		Clayey silt		
	Glacio-lacustrine sequence	~75'	 Organic silt Predominantly silt and silty clay Predominantly clay and silty clay <i>May include residuum in lower strata.</i>		
	Basal sands & gravels	0-5'	Sand/gravel within a clay matrix with sporadic clean sand/gravel intervals	 Deep groundwater 	H2-B
Pennsylvanian	Cherokee Group	0-75'	Shale, siltstone, coal, sandstone & limestone	 Shale bedrock 	H2-C
	Marmaton Group	0-80'	Shale, siltstone, limestone, sandstone & coal		H2-D
Mississippian	Ste. Genevieve Limestone	0-30'	Sandy Limestone	 Limestone bedrock 	H2-E

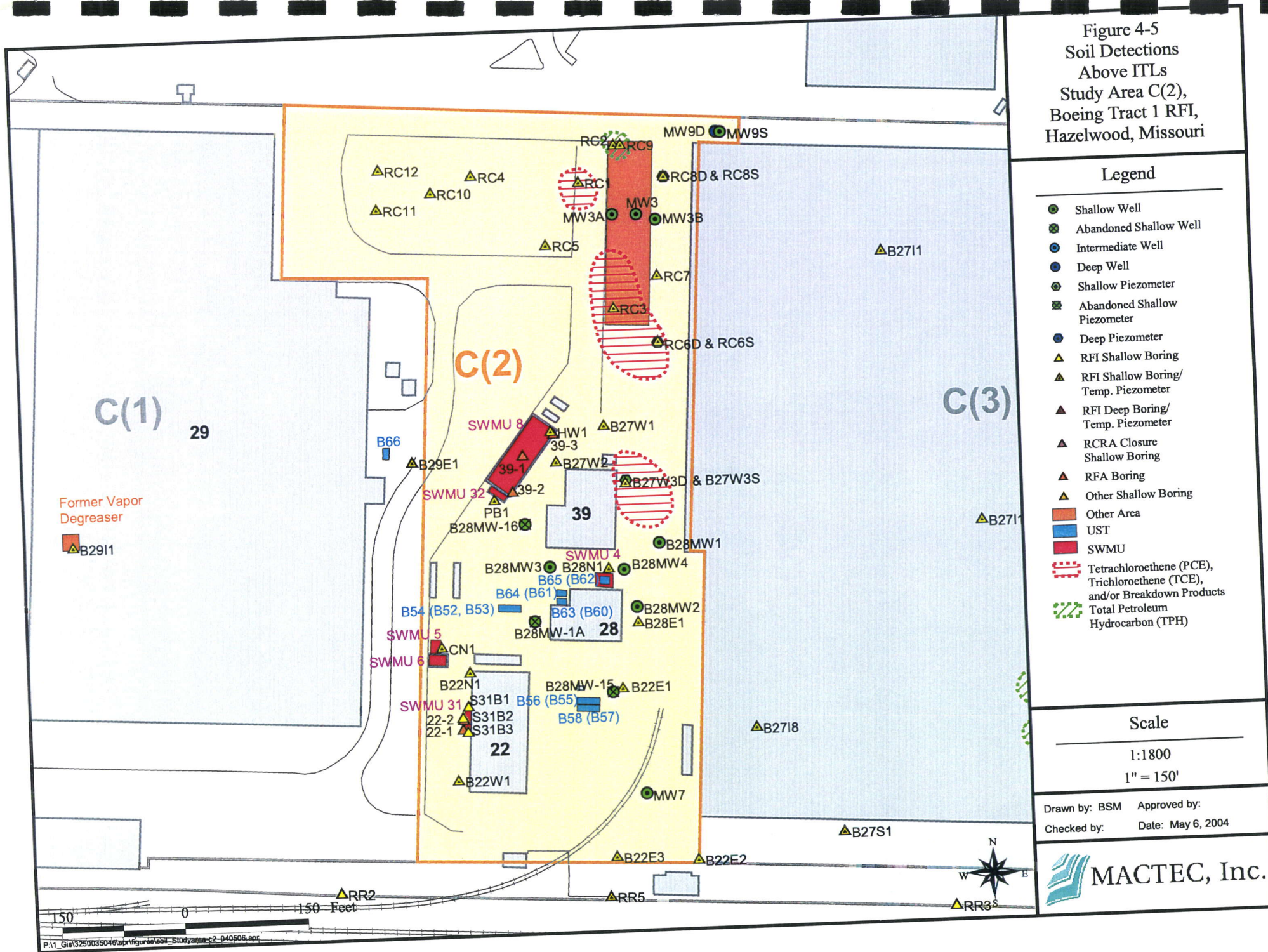
Drawn by: DLB Approved By:

Checked by: SEG Date: 5/8/04




Figure 2-11
Generalized Hydrogeological Column and Comparison to SLAPS Hydrostratigraphic Zones (HZ), Boeing Tract 1 RFI, Hazelwood, Missouri

Figure 4-5
Soil Detections
Above ITLs
Study Area C(2),
Boeing Tract 1 RFI,
Hazelwood, Missouri



Legend

	Shallow Well
	Abandoned Shallow Well
	Intermediate Well
	Deep Well
	Shallow Piezometer
	Abandoned Shallow Piezometer
	Deep Piezometer
	RFI Shallow Boring
	RFI Shallow Boring/ Temp. Piezometer
	RFI Deep Boring/ Temp. Piezometer
	RCRA Closure Shallow Boring
	RFA Boring
	Other Shallow Boring
	Other Area
	UST
	SWMU
	Benzene
	Polychlorinated Biphenyl (PCB)
	Tetrachloroethene (PCE), Trichloroethene (TCE), and/or Breakdown Products
	Total Petroleum Hydrocarbon (TPH)

$$1'' = 150'$$

Date: May 6, 2004



MACTEC, Inc.

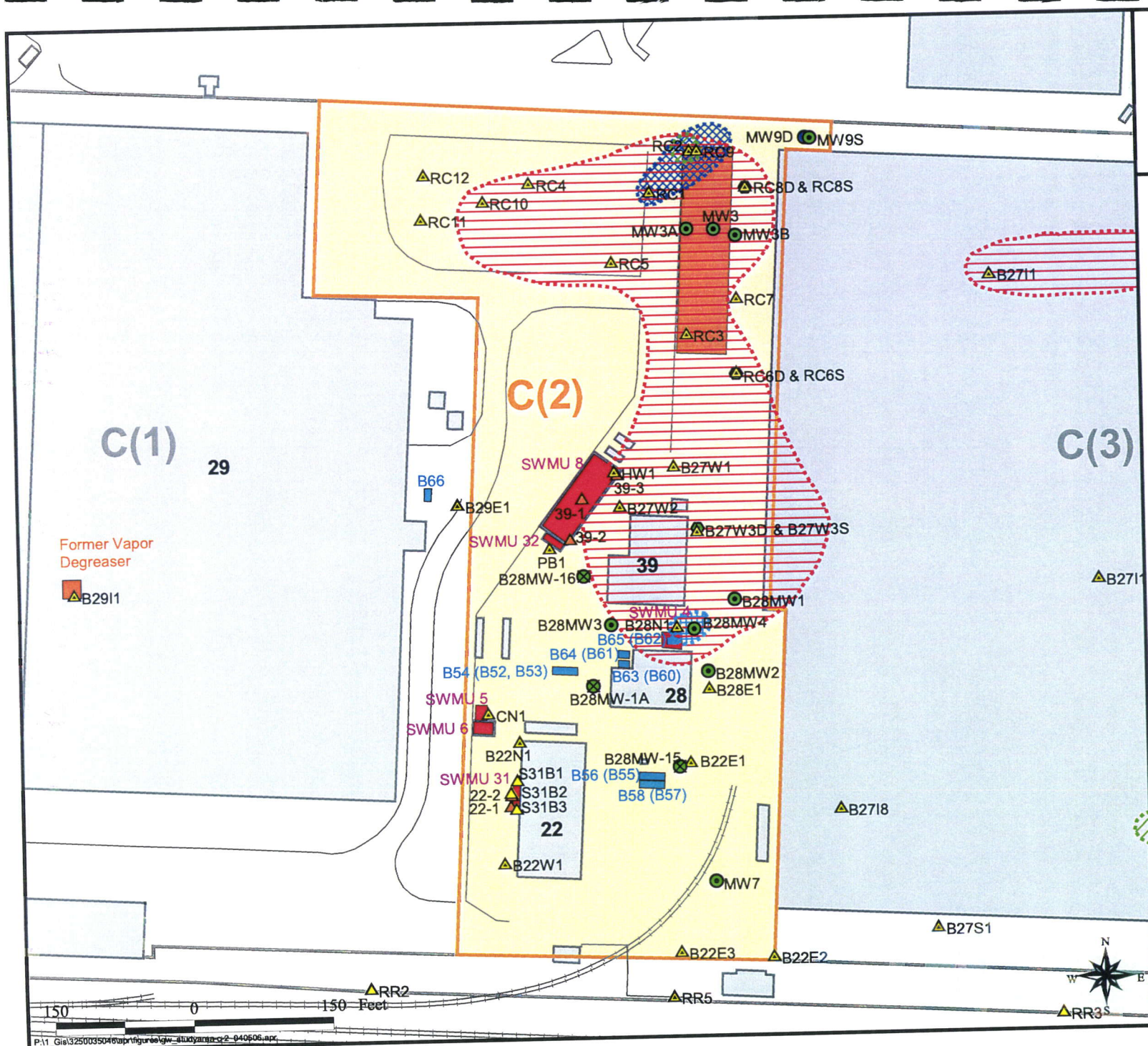


Figure 4-7
RFI Study Areas
C(3) & C(4) East,
Boeing Tract 1 RFI,
Hazelwood, Missouri

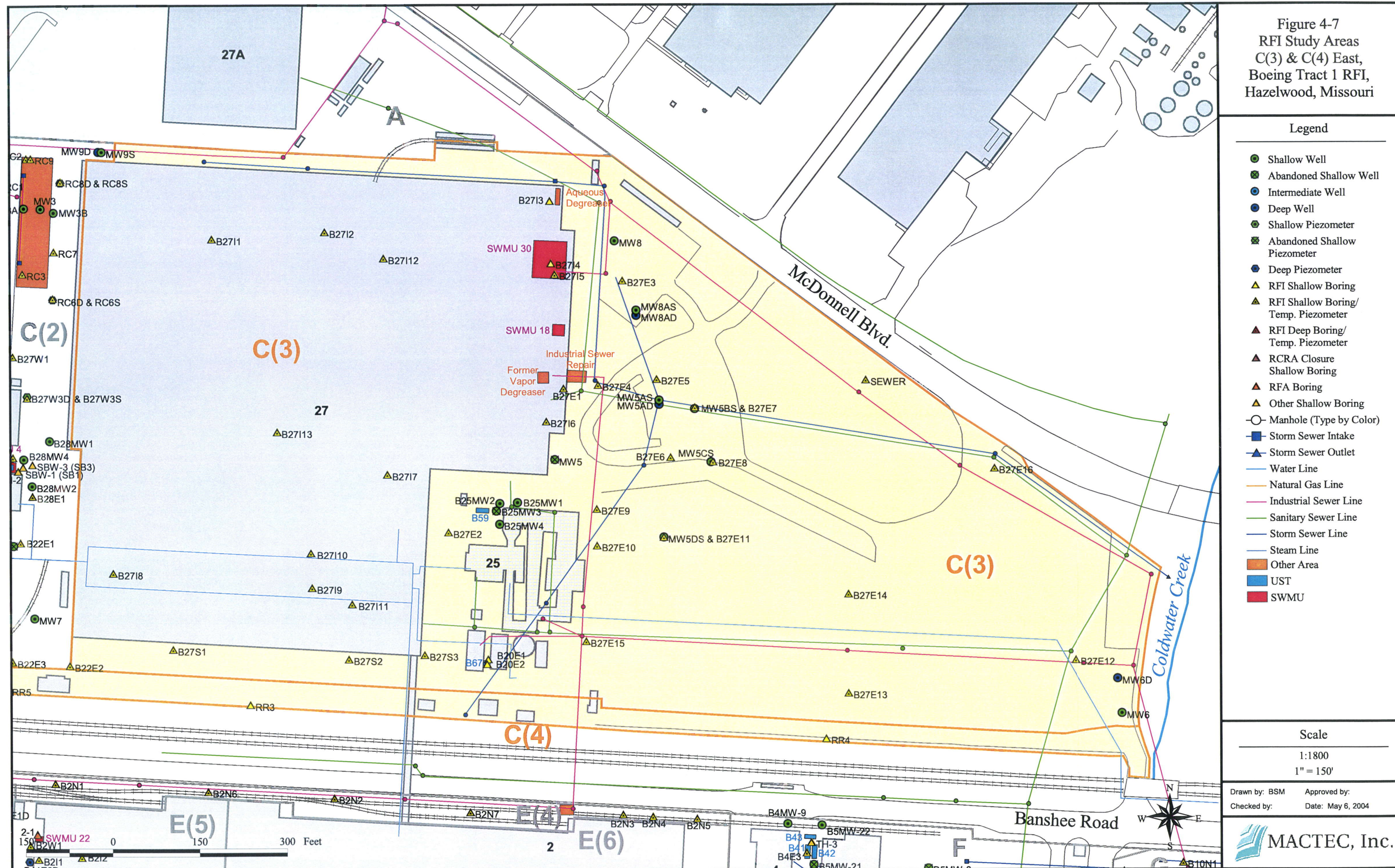
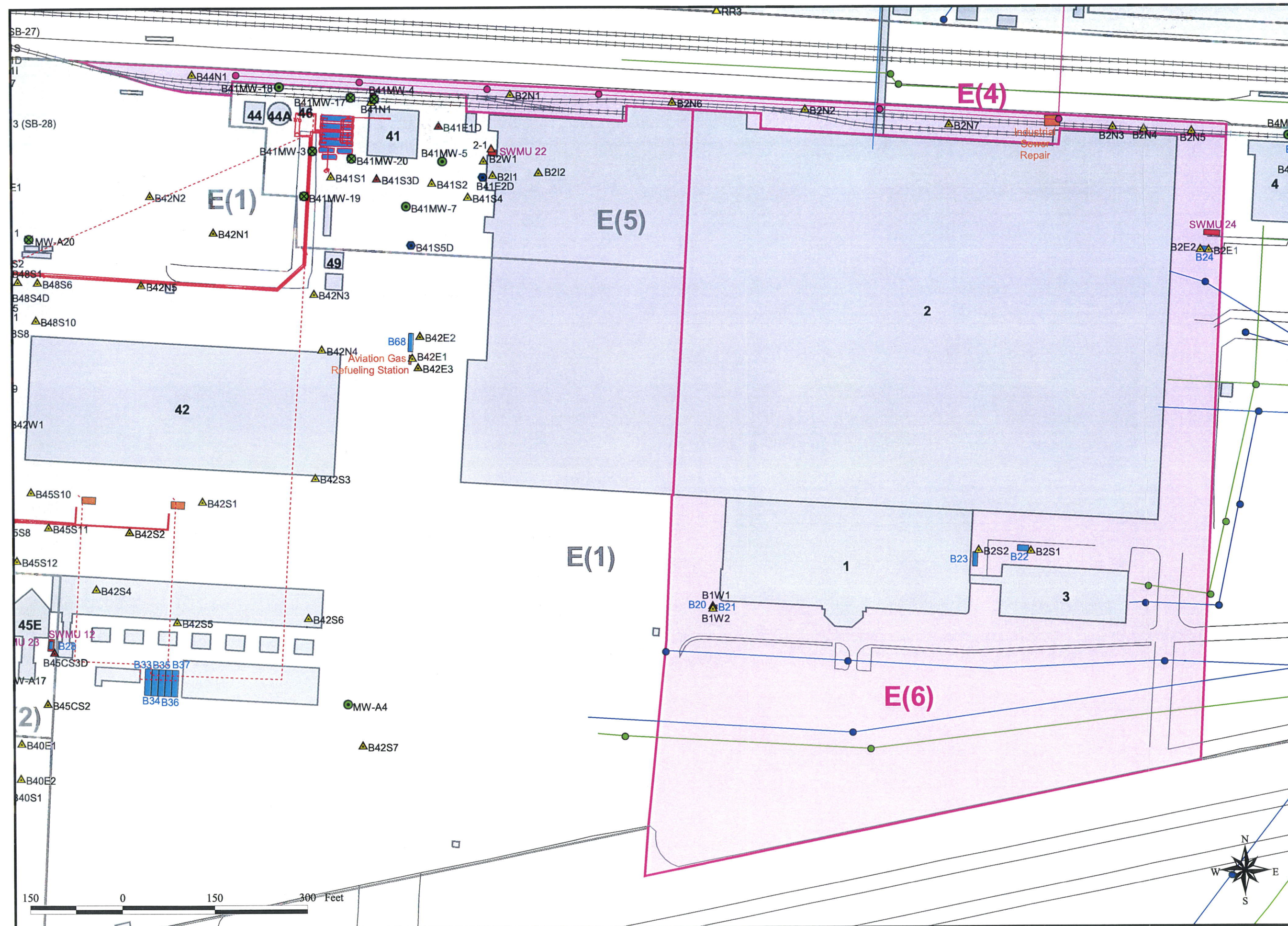


Figure 5-11
RFI Study Areas
E(4) & E(6),
Boeing Tract 1 RFI,
Hazelwood, Missouri



Legend

- Shallow Well
- ⊗ Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- ⊗ Abandoned Shallow Piezometer
- Deep Piezometer
- ▲ RFI Shallow Boring
- ▲ RFI Shallow Boring/Temp. Piezometer
- ▲ RFI Deep Boring/Temp. Piezometer
- ▲ RCRA Closure Shallow Boring
- ▲ RFA Boring
- ▲ Other Shallow Boring
- Manhole (Type by Color)
- Storm Sewer Intake
- Water Line
- ▲ Storm Sewer Outlet
- Industrial Sewer Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Jet Fuel Line
- Abandoned Fuel Line
- Other Area
- UST
- SWMU

Scale

1:1800

1" = 150'

Drawn by: BSM Approved by:
Checked by: Date: May 6, 2004

MACTEC, Inc.